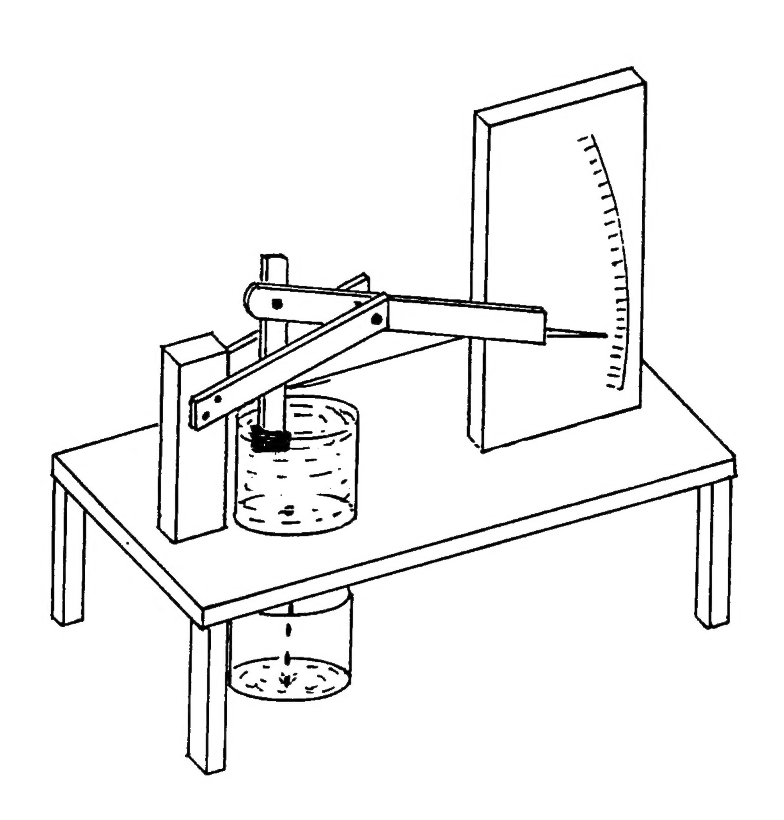
LOW COST EQUIPMENT for science and technology education

A Resource Document on low cost equipment that you can make and use.



Unesco

ED-86/WS/II0

LOW COST EQUIPMENT for science and technology education

VOLUME II

Unesco

PREFACE

This second resource document on low-cost equipment contains designs of equipment for science and technology education using inexpensive materials. In this issue the designs are presented in two parts; Part 1 follows the pattern of the first issue and contains 46 items suitable for construction in a school. Part II contains 20 designs which are more suitable for construction by an Equipment Production Unit or a school with a well-equipped workshop and trained technical teachers.

The designs have been submitted by the following institutions:

The Pedagogical Academy, Nicosia, Cyprus.

The Beijing Teaching Aids Centre, Hengshui Prefecture, Hebei Province, China.

National Educational Equipment Centre, Wahdat Colony, Lahore 16, Pakistan.

The Kyoto Municipal Science Centre for Youth, Kyoto 612, Japan.

The material has been compiled and edited by Mr. N. K LOWE.

From this second resource document on low-cost equipment we should like to receive your assistance and suggestions. Please inform us of any difficulties you may have experienced in constructing and using the designs. Also let us know if you have found them useful and how you used them in the learning environment.

In the event of an accident occurring through the use of any of the items, neither Unesco nor the editor or the submitting institutions can accept any responsibility.

Should you have a design which may be suitable for publication in future issues of this document or elsewhere, please send it, preferably in the format used in Part I of this document to:

Division of Science, Technical and Environmental
Education,
Unesco,
Place de Fontenoy,
75700 Paris.
France.

INTRODUCTION

The apparatus designs in this collection may be familiar to some, and new to other readers. The designs in Part I are not necessarily unique to the institutions who have submitted them, but they are accredited to them since it is believed that the designs have been found useful in the countries in which the institutions are located. The designs in Part II are all from one institution and, to the best of our knowledge, are unique to that institution. For the purpose of this document the designs have been edited, where necessary, to provide either a clearer drawing or text. The designs in Part I have been prepared in such a manner that they can easily be removed and photocopied/reproduced for use in teaching-learning activities.

In most cases the apparatus in Part I can either be prepared by the teacher or constructed by the pupils as part of a construct-and-use programme of learning. Very little initial practical skill is required to make the items; in fact, basic skills in woodworking, metalworking, etc., could be developed from the construction of the items as part of a modular science and technology programme of learning. The apparatus designs in Part II are more appropriate for construction in an Equipment Production Unit, both from the viewpoint of technical know-how and also in relation to availability of materials, tools, etc.

No attempt has been made to standardise the drawings according to Graphical Communication presentation. The sketches have been prepared (where possible as received) to provide maximum presentation within a limited space, and also to provide a 'picture' of the item. It would be possible to utilise the sketches in a formal Graphical Communications learning situation whereby the pupils use the designs and re-prepare them as if for use in an equipment production workshop.

Terms Used.

Generally, technical terms have been kept to a minimum in favour of easily read and understood descriptions. The following may help to clarify any possible non-familiarity with some of the terms used:-

Diameter	shown as dia, Dia. or Ø
Radius	shown as rad, Rad. or R.
Dimensions	usually in millimetres (mm) or centimetres (cm)
O.H.P.	Overhead Projector.
Loupe	Magnifying Glass.
Vinyl	see 'Notes on Plastics' below.
Styrofoam	A commercial term for expanded polystyrene as found in packing cases containing sensitive equipment, or as ceiling tiles. Sometimes referred to as Polystyrene.
Cell mat	Packing material for fragile items, made from plastic sheet with small pockets of trapped air.

Alligator Clip	Also known as a Crocodile Clip.
Duralumin	Aluminium Alloy.
18-8 Stainless Steel Wire	A particular type of stainless steel with low corrosive properties.
Heat Resistant Material	Asbestas was the common material, but, due to toxic properties, is no longer used. Sindanyo - a hard mixture of minerals, including Asbestas, is suitable.
Piezo-electric element	Some cigarette lighters operate on the piezo-electric effect - certain crystals develop a potential difference across their faces when subjected to a mechanical strain.

A Note on Plastics

The word 'plastic' is commonly used to refer to synthetic or semi-synthetic substances derived largely from petroleum, coal, salts, air and water. They are basically two groups of plastics, namely, Thermoplastic and Thermosetting.

Thermoplastic materials are those which soften with heat and harden with cooling - a cycle which can be repeated many times. Examples are: Acrylics, Polyvinyl Chloride (PVC), Polyethylene, Polypropylene, Polystyrene, Cellulose Acetate, Nylon, etc.

Thermosetting materials are those heat hardening plastics which soften when first heated but irreversibly harden on heating process. Examples are: Phenolic Resins, Urea-Formaldehyde Resin, Epoxy-Resin, Polyurethane, etc. (The term 'resin' is often applied to synthetic plastic materials before they are moulded to shape. It should not be confused with naturally occurring resins which have a different molecular structure).

Of particular interest to Part II of this document are Acrylics, P.V.C. and Epoxy Resin.

Acrylics	Depending upon the manufacturer they are marketed under such trade names as: Perspex; Oroglas; Plexiglass; etc. A Burn Test can be used to identify acrylics - when heated in a flame it will ignite and burn readily with a blue flame. Burning ceases (without smouldering) when the flame is removed. Vapours have a strong sweet odour.
Polyvinyl Chloride (P.V.C)	The popular name for P.V.C. is 'Vinyls'. P.V.C. is marketed under a variety of trade names such as Darvic, Nylex, Breon, Corvic, etc. A Burn Test can be used to identify P.V.C. - when heated in a flame it is slow to ignite and burns with a yellow flame. It gives off white smoke and has an acrid odour. When removed from the flame it ceases to burn.

Epoxy Resin

These resins have a catalyst added to them which brings about an irreversible chemical change. During this change heat is given off and the liquid resin gradually changes to a solid. Although used for many purposes their function as a multi-purpose adhesive is of particular importance.

Adhesives for Plastics:

Acrylics

Suitable adhesives are Solvents such as chloroform, ethylene dichloride, triclorethylene and glacial acetic acid. Coat both surfaces with the solvent and apply pressure until bonded. The surfaces must be clean, smooth, and fit together without gaps.

Special Acrylic Cements are available commercially and usually contain acrylic materials dissolved in solvents. A suitable cement can be made by dissolving small pieces of acrylic in chloroform. Leave for about one week in an air-tight jar before use to allow complete dissolving of the acrylic. Epoxy resins are also suitable adhesives.

Vinyls

Suitable adhesives are: Special Cements (P.V.C. dissolved in chlorinated solvent); some Rubber Solutions which have chlorinated solvents; and Welding using a hot gas welding gun and P.V.C. filler rods. This latter is the most common means of joining rigid P.V.C. material. (P.V.C. sheeting is usually joined by an electrically heated sealing tool similar to the action of a soldering iron).

Epoxy Resins

A widely available adhesive of this type is marketed under the trade name of 'Araldite'. In this particular type, equal quantities of resin and hardener are mixed together. Both surfaces to be glued are coated and the joint held under pressure until set. Other types may require different proportions for mixing.

Cyanoacrylate Adhesives

These are a recently developed range of 'instant' adhesives. Care should be exercised in their use.

Safety Precautions:

Adhesives

Solvent-based Adhesives	Implement all safety procedures applicable to the use of solvents such as good ventilation, no naked flames, avoid inhalation of fumes, avoid skin contact.
Epoxy Resins	Avoid skin contact.
Cyanoacrylate Adhesives	Extreme caution is needed in using and handling alphacyanoacrylate adhesives since they are instantaneous and can bond skin to skin. Strict control of these 'Instant' adhesives should be implemented. Use gloves and eye protection (to avoid accidental touching/wiping of the eyes) and seek medical attention if adhesion of parts of the body occurs.

Electrical

All items in Part 1 requiring an electrical supply for their operation are for use on dry cell batteries. They must not be connected to a low-voltage power pack or the electrical mains supply.

Certain items in Part II require connections to a Power Pack. The user should ensure that all items are electrically safe to use before switching on the power supply.

CONTENTS

PART 1

PART II

55. A Microbalance.
56. Tullgren and Bearmann Apparatus.
57. Respiration Apparatus.
58. Gas Generator Type A.
59. Gas Generator Type B.
60. Dew Point Apparatus.
61. A Eudiometer.
62. Oxidation and Reduction Apparatus.
63. Air Column Resonance.
64. Air Moisture Apparatus.
65. Electrolysis of Water.
66. Polarizer.

PART I

1- ITEM

AIR FLOW APPARATUS.

2- PURPOSE

To demonstrate that there is a relationship between pressure and the flow of air.

3- INFORMATION SUBMITTED BY

Beijing Teaching Aids Centre, Hengshui Prefecture, Hebei Province, China.

4- LINE DRAWING OF PROTOTYPE

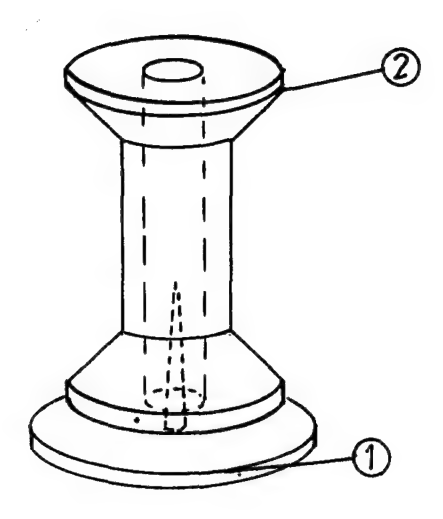


FIG . A.

5- MATERIALS FOR CONSTRUCTION

Components	Qty	Materials Required	Dimensions
1. Disc.	1.	Stiff paper.	to suit dia. of spool.
2. Spool.	1.	Cotton reel.	as available.
	1.	Pin. (large)	

Tools: Scissors

6- CONSTRUCTION DETAILS

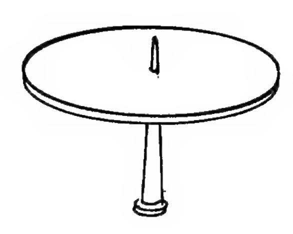


Fig. 1. Cut a disc of approximately 30mm dia. from a piece of stiff paper. Push a long pin through the centre of the disc (a pin used in optical experiments would be suitable).

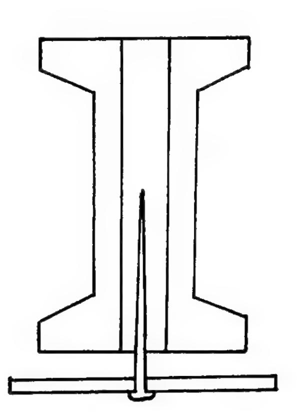


Fig. 2. Arrange the apparatus as shown in Fig. 2.

7- METHOD OF USE

Blow vertically down through the hole in the spool and at the same time lift the spool upwards. The paper disc will be seen to rise up with the spool. Stop blowing and the paper disc will fall down.

8- COMMENTS

Ensure that the paper disc is larger in diameter than the diameter of the bottom face of the spool.

1- ITEM

AIR PRESSURE APPARATUS.

2- PURPOSE

To demonstrate that air exists and to show the effect of air pressure.

3- INFORMATION SUBMITTED BY

Beijing Teaching Aids Centre, Hengshui Prefecture, Hebei Province, China.

4- LINE DRAWING OF PROTOTYPE

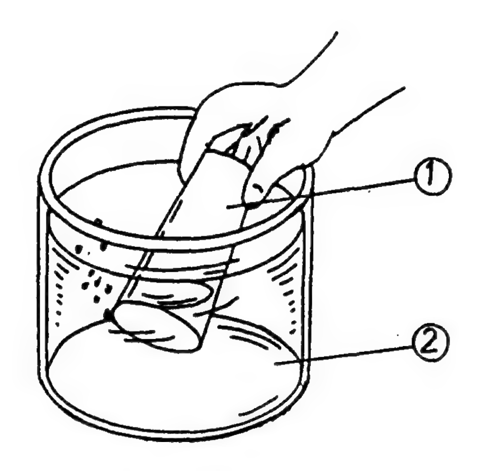


FIG. A.

5- MATERIALS FOR CONSTRUCTION

Components	Qty	Materials Required	Dimensions
1. Air container.	1.	Glass tumbler.	as available.
2. Water container.	1.	Glass trough.	as available.
		Paper.	

6- CONSTRUCTION DETAILS

7- METHOD OF USE

Place a wad of screwed up paper in the bottom of the glass tumbler. Fill the glass trough with water. Turn the tumbler upside down and push it into the water. Due to the air trapped in the glass the water will not wet the paper but will remain below it.

8- COMMENTS

Ensure that there is enough water in the trough to cover the glass tumbler. Insert the tumbler into the water in an almost vertical position to ensure that the maximum amount of air is trapped in the glass.

1- ITEM

SIMPLE BALANCE. (i)

2- PURPOSE

To demonstrate that air has weight.

3- INFORMATION SUBMITTED BY

Beijing Teaching Aids Centre, Hengshui Prefecture, Hebei Province, China.

4- LINE DRAWING OF PROTOTYPE

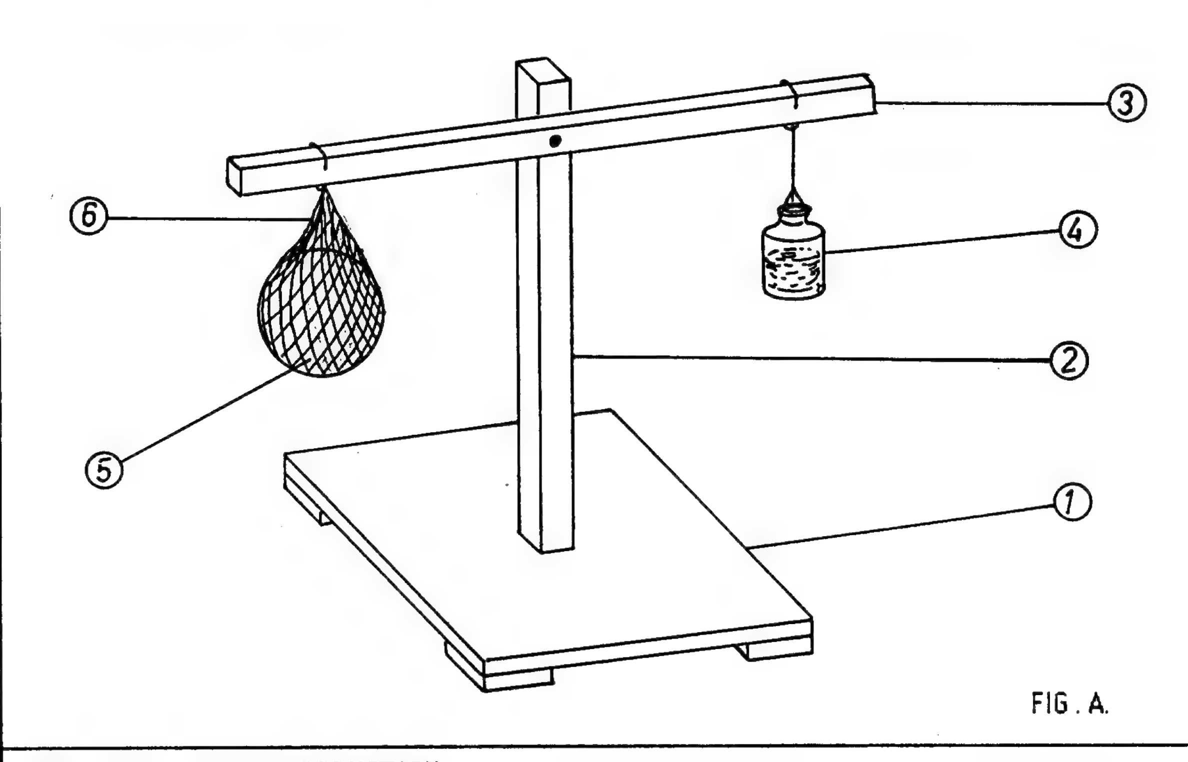


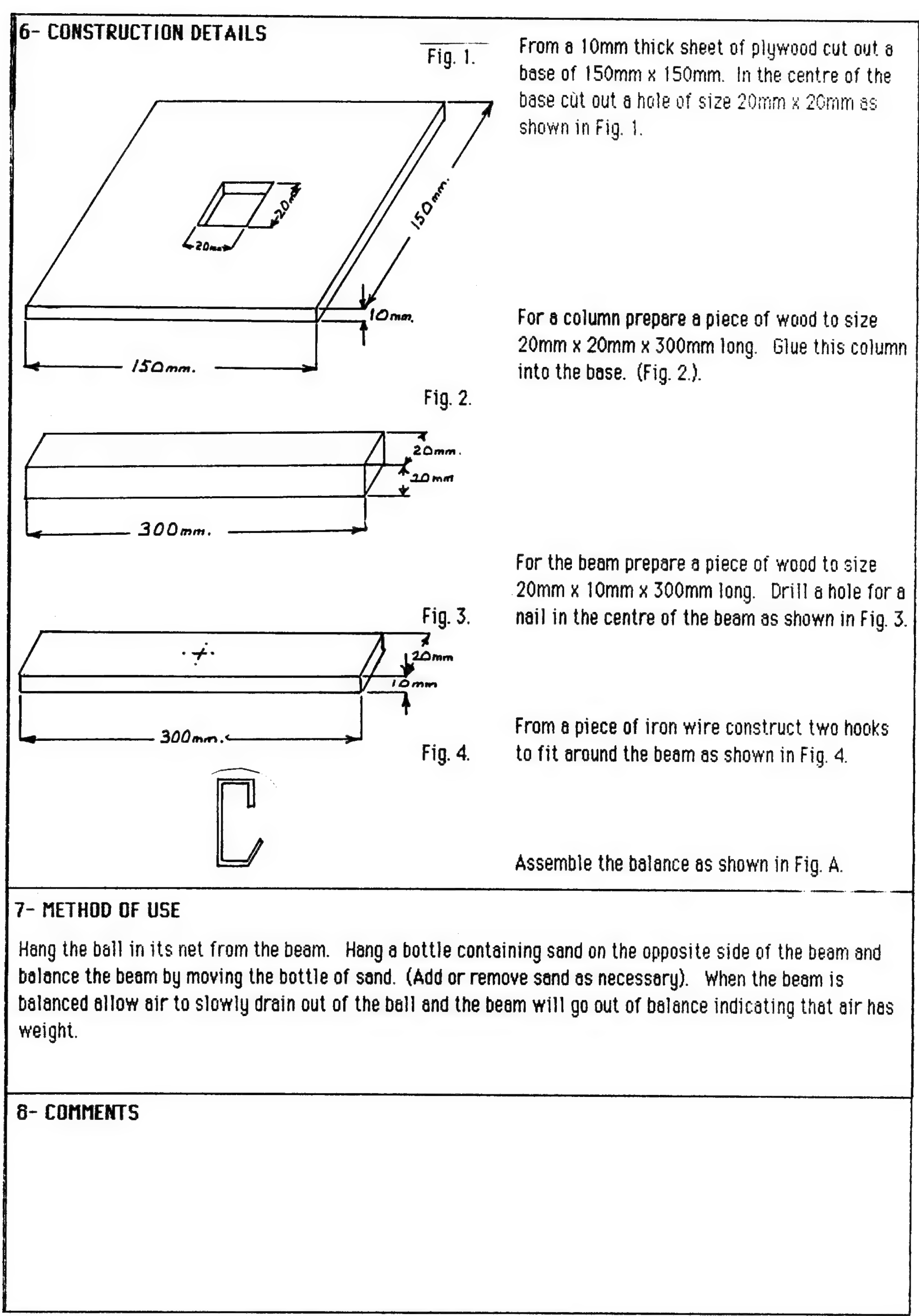
FIG. A.

5- MATERIALS FOR CONSTRUCTION

Components	Qty	Materials Required	Dimensions
1. Base.	1.	Wood.	150mm x150mm x 10mm
2. Column.	1.	Wood.	300mm x 20mm x 20mm.
3. Beam.	1.	Wood.	300mm x 20mm x 10mm.
4. Mass.	1.	Bottle (containing sand)	
5. Air container.	1.	Inflatable ball.	
6. Net.	1.	Net for ball.	
		Iron wire.	
		Thread.	

Tools: Wood saw; hammer; chisel; pliers; wood glue.

6- CONSTRUCTION DETAILS



From a 10mm thick sheet of plywood cut out a base of 150mm x 150mm. In the centre of the base cut out a hole of size 20mm x 20mm as shown in Fig. 1.

For a column prepare a piece of wood to size 20mm x 20mm x 300mm long. Glue this column into the base. (Fig. 2.).

For the beam prepare a piece of wood to size 20mm x 10mm x 300mm long. Drill a hole for a nail in the centre of the beam as shown in Fig. 3.

From a piece of iron wire construct two hooks to fit around the beam as shown in Fig. 4.

Assemble the balance as shown in Fig. A.

7- METHOD OF USE

Hang the ball in its net from the beam. Hang a bottle containing sand on the opposite side of the beam and balance the beam by moving the bottle of sand. (Add or remove sand as necessary). When the beam is balanced allow air to slowly drain out of the ball and the beam will go out of balance indicating that air has weight.

8- COMMENTS

1- ITEM

SIMPLE BALANCE. (ii)

2- PURPOSE

To construct a simple balance and to show the principle of balance.

3- INFORMATION SUBMITTED BY

Beijing Teaching Aids Centre, Hengshui Prefecture, Hebei Province, China.

4- LINE DRAWING OF PROTOTYPE

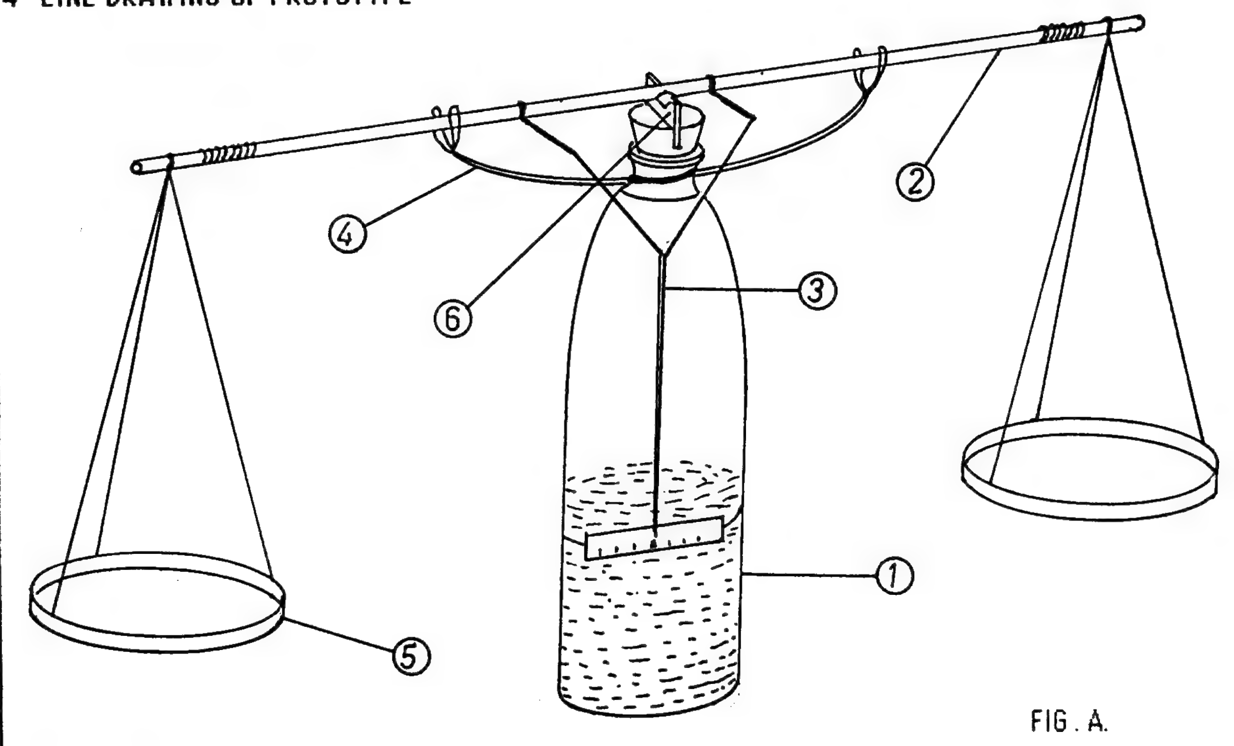


FIG. A.

5- MATERIALS FOR CONSTRUCTION

Components	Qty	Materials Required	Dimensions
1. Support.	1.	Glass Bottle.	as available.
2. Beam.	1.	Chopstick (or dowel rod)	as available.
3. Pointer.	1.	Iron Wire.	approx. 1mm. dia.
4. Beam Support.	1.	Iron Wire.	approx. 1.5mm dia.
5. Pans.	2.	Plastic Lids.	
6. Pivot.	1.	Razor Blade.	
	1.	Cork.	
		Sand.	
		Thin metal sheet.	
		Thread.	

Tools: Tin snips, knife, pliers (long nose)

6- CONSTRUCTION DETAILS

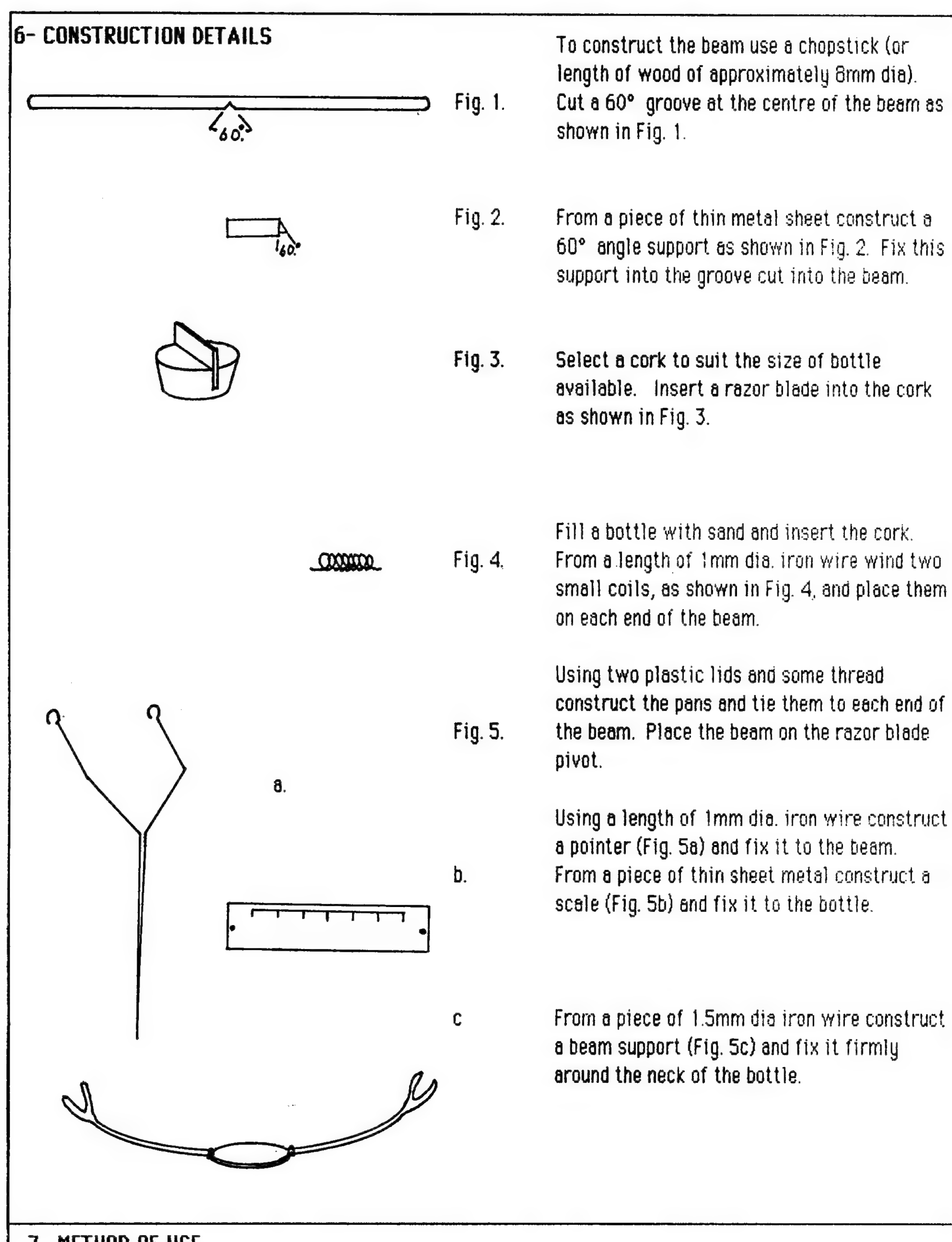


Fig. 1. To construct the beam use a chopstick (or length of wood of approximately 8mm dia). Cut a 60° groove at the centre of the beam as shown in Fig. 1.

Fig. 2. From a piece of thin metal sheet construct a 60° angle support as shown in Fig. 2. Fix this support into the groove cut into the beam.

Fig. 3. Select a cork to suit the size of bottle available. Insert a razor blade into the cork as shown in Fig. 3.

Fill a bottle with sand and insert the cork.

Fig. 4. From a length of 1mm dia. iron wire wind two small coils, as shown in Fig. 4, and place them on each end of the beam.

Fig. 5. Using two plastic lids and some thread construct the pans and tie them to each end of the beam. Place the beam on the razor blade pivot.

a. Using a length of 1mm dia. iron wire construct a pointer (Fig. 5a) and fix it to the beam.

b. From a piece of thin sheet metal construct a scale (Fig. 5b) and fix it to the bottle.

c From a piece of 1.5mm dia iron wire construct a beam support (Fig. 5c) and fix it firmly around the neck of the bottle.

7- METHOD OF USE

Assemble the apparatus as shown in Fig. A. Adjust the beam for balance using the two coils (riders) at each end of the beam.

8- COMMENTS

Masses can be made using clay; bottles containing sand etc but should be checked against known masses.

1- ITEM

A SIMPLE BALANCE. (iii)

2- PURPOSE

For investigating the apparent loss of weight of a body in a liquid (Archimedes Principle).

3- INFORMATION SUBMITTED BY

Pedagogical Academy, Nicosia, Cyprus.

4- LINE DRAWING OF PROTOTYPE

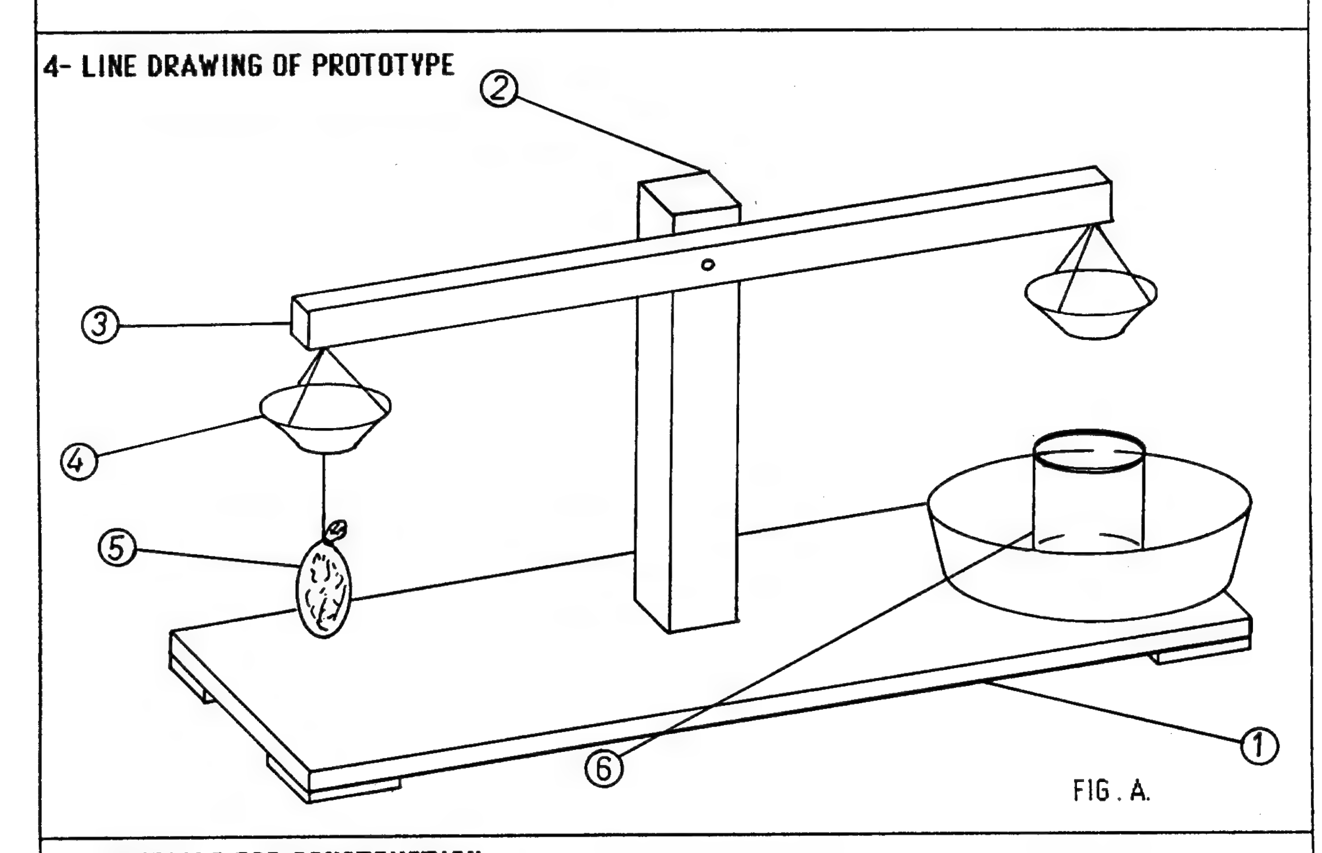


FIG. A.

5- MATERIALS FOR CONSTRUCTION

Components	Qty	Materials Required	Dimensions
1. Base.	1.	Wood.	400mm x 120mm x 10mm.
2. Pillar.	1.	Wood.	300mm x 30mm x 30mm.
3. Beam.	1.	Wood.	300mm x 30mm x 20mm.
4. Pan.	2.	Plastic Bowls.	as available.
5. Object.	1.	Bag containing sand.	
6. Water Container.	1.	Large glass Beaker.	as available.
		Washing up Bowl.	
		Nails.	
		Thread.	
		Small hooks.	

Tools: Woodsaw; hammer; scissors; drill and drill bit;

6- CONSTRUCTION DETAILS

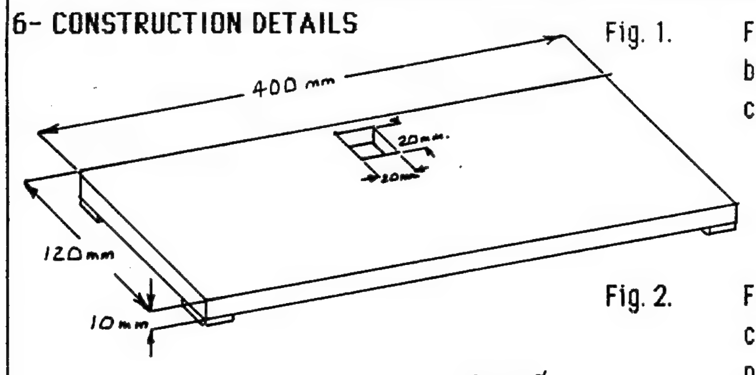


Fig. 1. From a sheet of 10mm wood construct the base as shown in Fig. 1. Using the drill and chisel cut out the hole for the pillar.

Fig. 2. From a piece of wood 30mm x 20mm construct the beam. Drill a hole at the centre point of the beam as shown in Fig. 2.

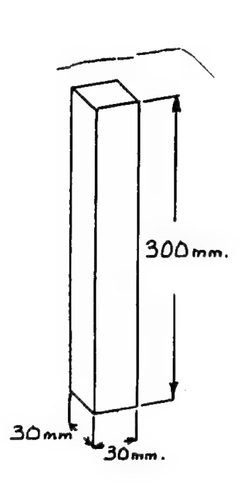


Fig. 3. A piece of wood of size 20mm x 20mm is used to make the pillar as shown in Fig. 3. Glue and nail the pillar into the hole in the base.

Fix the beam to the pillar using a 2mm dia nail as a pivot. Place a small washer between the beam and the pillar so that the beam can swing freely. Suspend the pans from each end of the beam, using small hooks screwed at the underside of the beam, at an equal distance from the pivot. Adjust the beam so that it settles horizontally by inserting small nails into the lighter side of the beam.

7- METHOD OF USE

Suspend the bag with the sand inside from the left hand pan. Place suitable masses into the right hand pan until balance is restored. Fill the glass with water and stand it in the bowl. Carefully place the bowl under the bag of sand and lower the bag into the water. The water overflows into the bowl and the beam goes out of balance. The beam can be brought back into balance by pouring the water, which overflowed into the bowl, into the pan above the sand bag (leaving the sand bag immersed in the water in the glass). This demonstrates Archimede's Principle which indicates that the apparent loss in weight is equal to the weight of water displaced.

8- COMMENTS

1- ITEM

BUOYANCY APPARATUS.

2- PURPOSE

To demonstrate the effect of changing atmospheric pressure on buoyancy.

3- INFORMATION SUBMITTED BY

National Educational Equipment Centre, Lahore 16, Pakistan.

4- LINE DRAWING OF PROTOTYPE

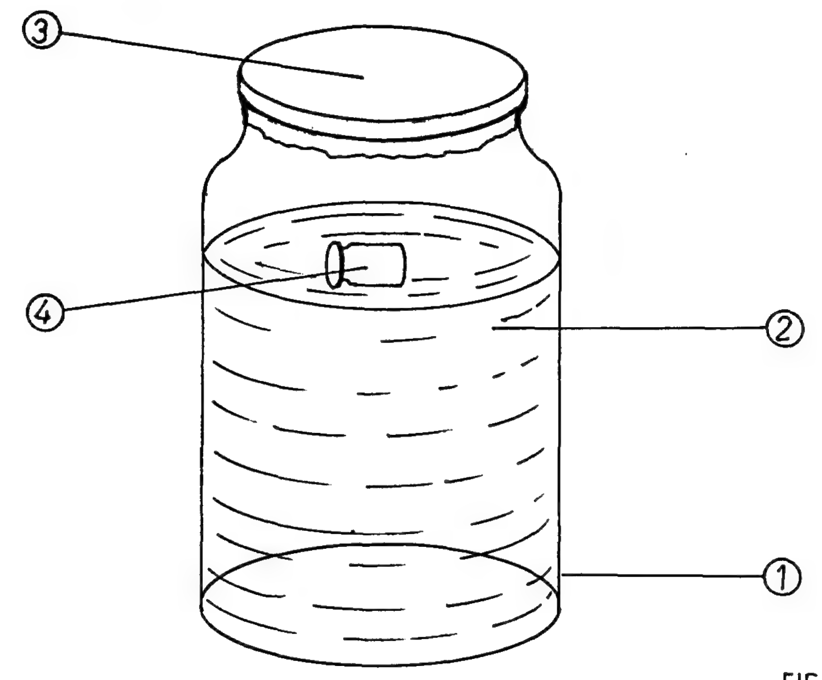


FIG. A.

5- MATERIALS FOR CONSTRUCTION

Components	Qty	Materials Required	Dimensions
1. Container.	1.	Glass Jar.	
2. Liquid.		Water.	
3. Membrane	1.	Rubber Sheet. (from a balloon).	
4. Floating Object.	1.	Vaccine injection bottle with air-tight rubber lid.	

6- CONSTRUCTION DETAILS

Half fill the glass jar with clean water.

Ensure that the small vaccine (medicine) bottle is clean and that the rubber lid is air-tight. Put the bottle into the jar and it should float in the water. From the rubber balloon cut out a flat piece of rubber to go over the neck of the jar. Place the rubber over the jar mouth and stretch it tight. Fix it in place using a rubber band, as shown in Fig. A., to form a taut diaphragm.

7- METHOD OF USE

Using your hand apply pressure to the rubber diaphragm. The air pressure inside the jar will increase (as also will that in the small bottle). The bottle will be seen to sink lower in the water.

8- COMMENTS

It may be necessary to 'weight' the small bottle so that it is partially submerged, using lead shot. Ensure that the lid is air-tight after adding the weights.

1- ITEM

DENSITY OF LIQUIDS APPARATUS.

2- PURPOSE

To demonstrate that objects can sink in some liquids and float in others.

3- INFORMATION SUBMITTED BY

National Educational Equipment Centre, Lahore 16, Pakistan.

4- LINE DRAWING OF PROTOTYPE

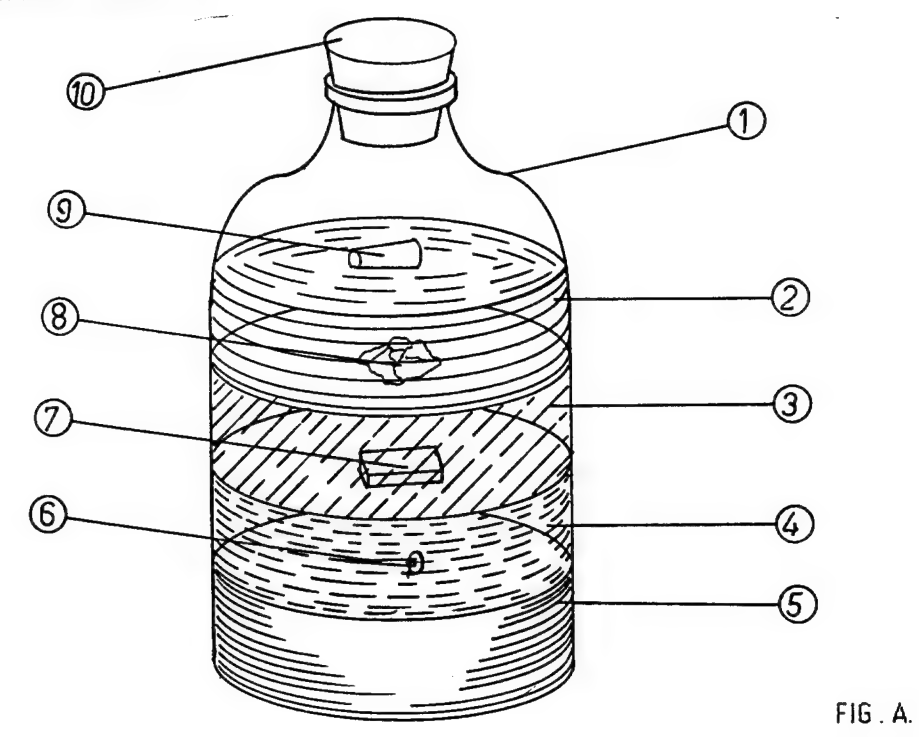


FIG. A.

5- MATERIALS FOR CONSTRUCTION

Components	Qty	Materials Required	Dimensions
1. Container.	1.	Glass Bottle.	
2. Kerosene.			
3. Water.			
4. Carbon tetrachloride.			
5. Mercury.			
6. Nail.			
7. Ebonite Block.			
8. Wax Block.			
9. Cork Stopper.			
10. Rubber Stopper.			

6- CONSTRUCTION DETAILS

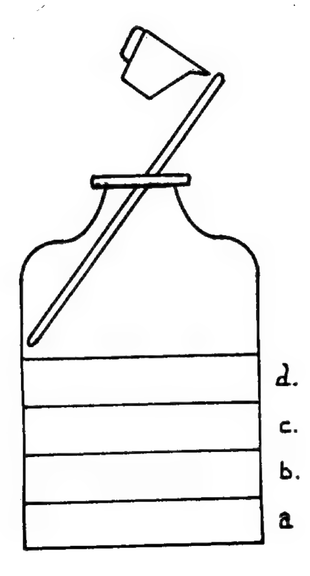


Fig. 1.

Ensure that the glass bottle is clean and dry. Pour into the bottle an amount of mercury (See Fig. 1a). Lower a nail into the bottle such that it rests on the surface of the mercury. Using a stirring rod (or similar rod) slowly introduce the carbon tetrachloride onto the top of the mercury as shown in Fig. 1.b. Lower a piece of Ebonite onto the surface of the carbon tetrachloride. Using the same procedure slowly pour some water up to level c. and then lower a wax block to float on the surface of the water. Again, using the rod, slowly pour some kerosene onto the surface of the water and lower a cork which will float on the water. Finally insert a stopper into the bottle.

7- METHOD OF USE

By carefully preparing this apparatus it can be used to introduce the idea of liquids having different densities/ relative densities, as well as introducing the idea of densities of solids.

8- COMMENTS

Ensure that the wax used will float on the water and not on the Kerosene as well. This demonstration apparatus could be made using other liquids.

1- ITEM

BOILING POINT AND PRESSURE APPARATUS.

2- PURPOSE

To study the relationship between the boiling point of water and pressure.

3- INFORMATION SUBMITTED BY

Beijing Teaching Aids Centre, Hengshui Prefecture, Hebei Province, China.

4- LINE DRAWING OF PROTOTYPE

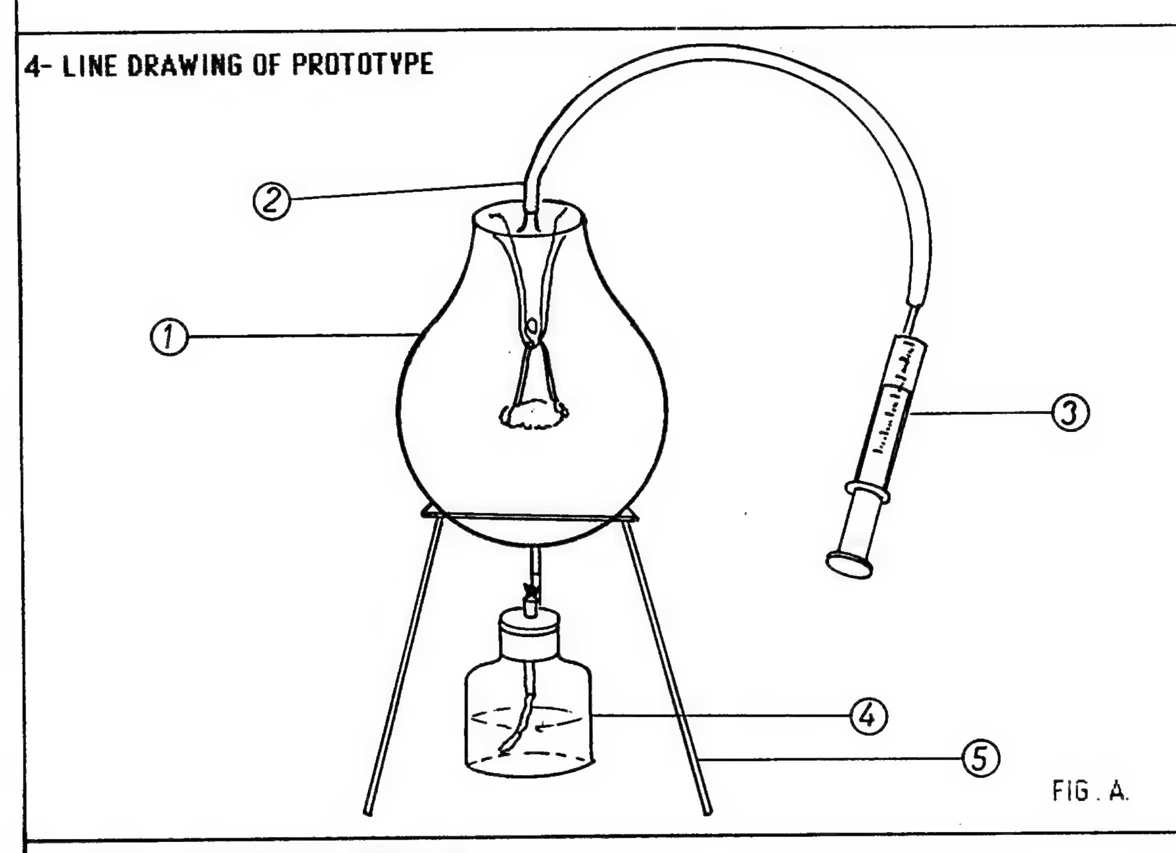


FIG. A.

5- MATERIALS FOR CONSTRUCTION

Components	Qty	Materials Required	Dimensions
1. Container.	1.	Electric Light Bulb.	as available
2. Connecting tube.	1.	Rubber tube small bore.	approx. 350mm
3. Pressure adjustor.	1.	Syringe.	as available.
4. Heater.	1.	Spirit Burner.	
5. Stand	1.	Tripod.	

Tools: Long-nosed pliers, small file.

6- CONSTRUCTION DETAILS

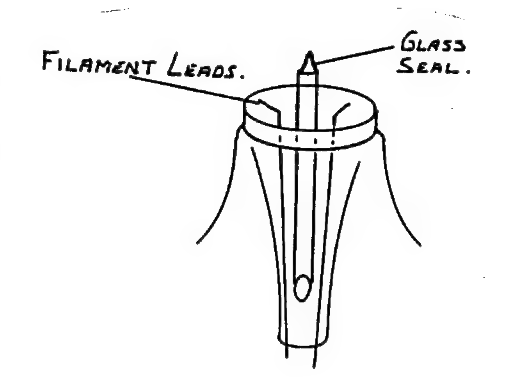


Fig. 1.

Gently heat the base of an old bulb over a spirit burner. Gently twist the bulb whilst heating and gradually pull the base off from the bulb. Take care not to break the air exhaust tube when removing the cap. With a pair of long nosed pliers gently remove the glass seal from the end of the air exhaust tube. (Fig. 1.)

Using a syringe, inject water into the bulb via the air exhaust tube. Connect a length of rubber tube to the air exhaust tube.

Stand the bulb on a tripod over a spirit lamp. Remove the needle from the syringe and connect the syringe to the rubber tube.

7- METHOD OF USE

Remove the syringe from the rubber tube. Light the burner to heat the water. Adjust the syringe plunger to the half way position. The Higher the Pressure the Higher the Boiling Point. When the water is boiling attach the syringe to the rubber tube. Push the plunger forward a little to give a higher pressure within the bulb and the water will be seen to stop boiling. After continued heating (higher temperature) the water will again boil. This procedure could be repeated. The Lower the Pressure the Lower the Boiling Point. When the water is boiling remove the burner and wait until the water stops boiling. Attach the syringe to the rubber tube and pull back the plunger a little to give a lower pressure in the bulb. The water will be seen to be boiling again (lower temperature); This procedure could be repeated.

8- COMMENTS

Wear eye protectors when working with glass.

1- ITEM

SIMPLE HYDRAULICS APPARATUS.

2- PURPOSE

To demonstrate the principle of hydraulics.

3- INFORMATION SUBMITTED BY

Beijing Teaching Aids Centre, Hengshui Prefecture, Hebei Province, China.

4- LINE DRAWING OF PROTOTYPE

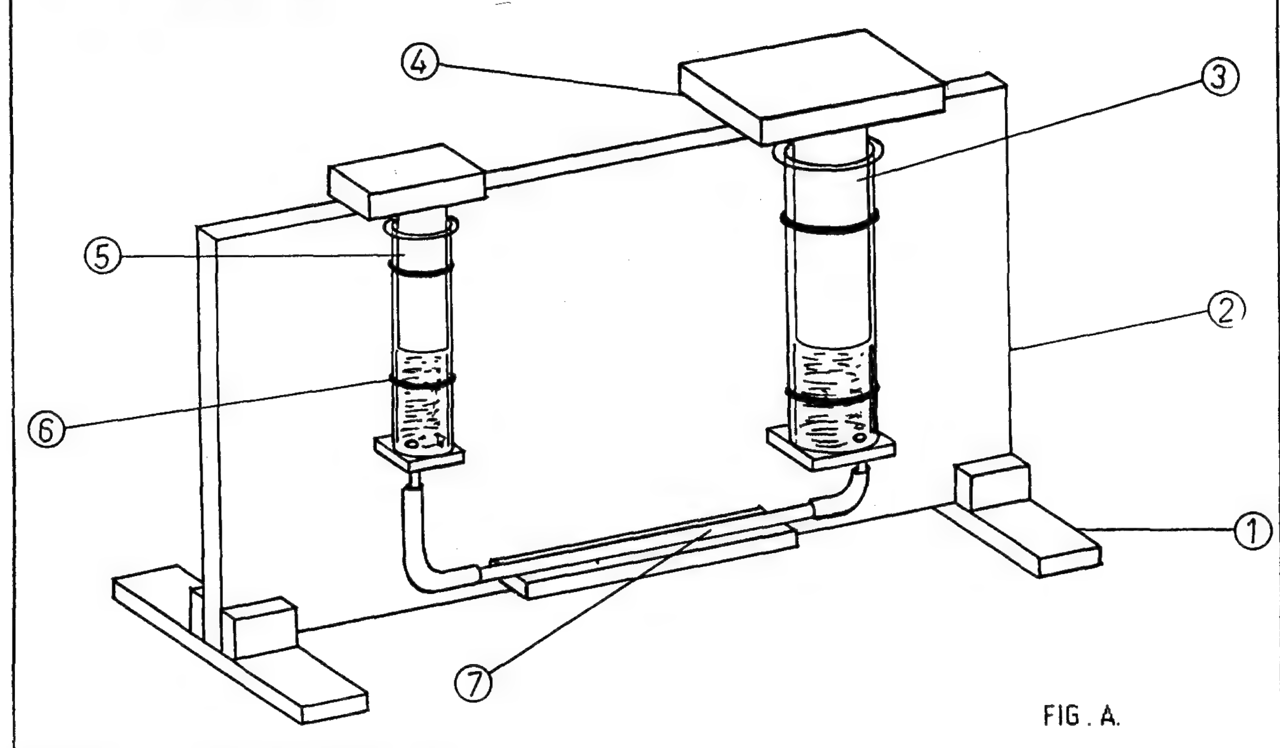


FIG. A.

5- MATERIALS FOR CONSTRUCTION

Components	Qty	Materials Required	Dimensions
1. Stand.	2.	Plywood.	140mm x 20mm x 10mm.
2. Baseboard.	1.	Plywood.	300mm x 150mm x10mm
3. Piston.	1.	Syringe.	size: 50ml.
4. Masses.	2.	Iron (or other suitable material).	One of 100g. One of 50g.
5. Piston.	1.	Syringe.	Size: 10ml.
6. Clamps.	4.	Iron wire.	approx. 2mm dia. x 25cm long.
7. Connecting tube.	1.	Glass tube.	approx. 4mm i.d. x 30cm long.
		Rubber tubing. Tools: Woodsaw, hammer, nails, pliers, drill and drill bit, chisel, wood glue.	

6- CONSTRUCTION DETAILS

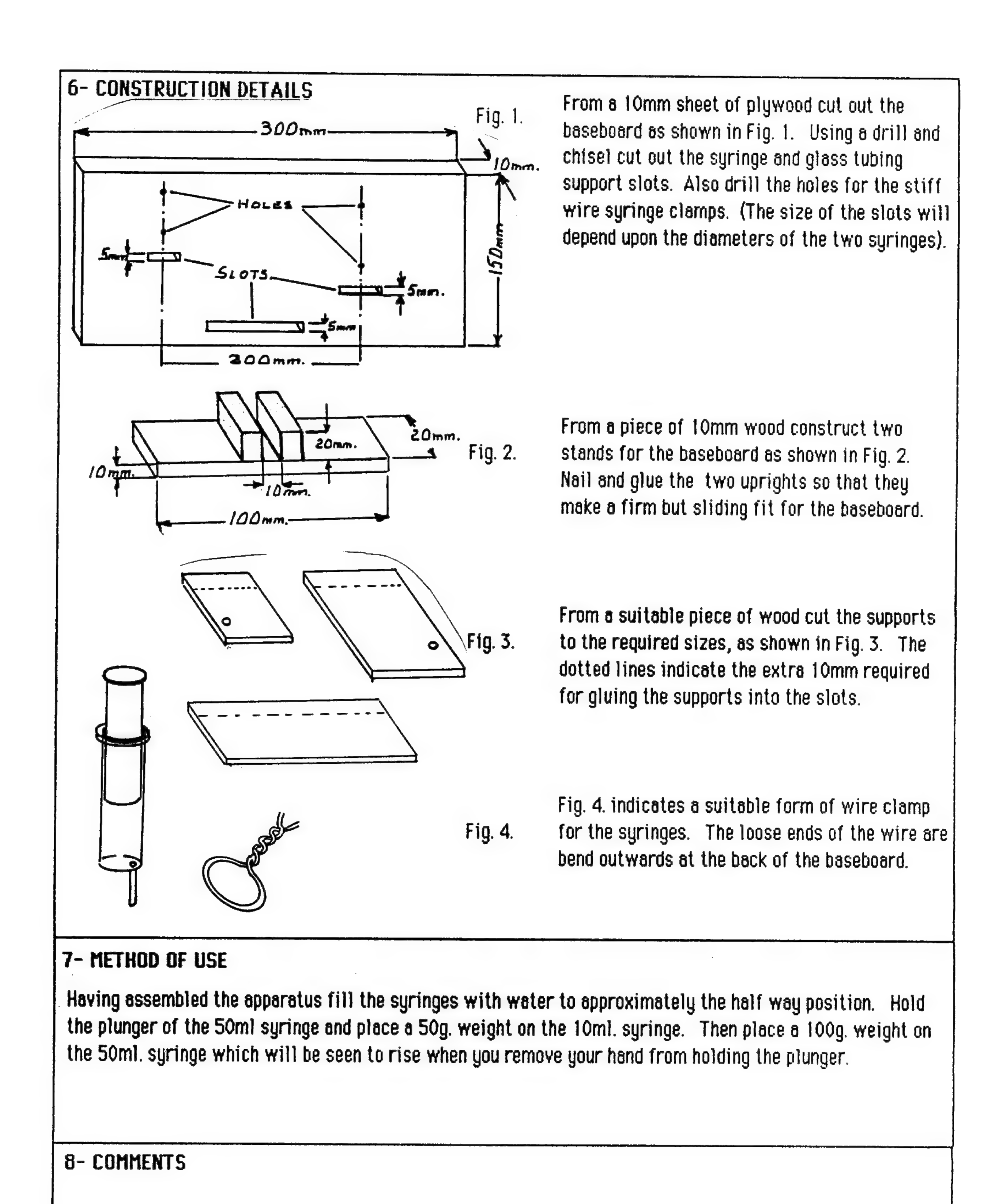


Fig. 1.

From a 10mm sheet of plywood cut out the baseboard as shown in Fig. 1. Using a drill and chisel cut out the syringe and glass tubing support slots. Also drill the holes for the stiff wire syringe clamps. (The size of the slots will depend upon the diameters of the two syringes).

Fig. 2.

From a piece of 10mm wood construct two stands for the baseboard as shown in Fig. 2. Nail and glue the two uprights so that they make a firm but sliding fit for the baseboard.

Fig. 3.

From a suitable piece of wood cut the supports to the required sizes, as shown in Fig. 3. The dotted lines indicate the extra 10mm required for gluing the supports into the slots.

Fig. 4.

Fig. 4. indicates a suitable form of wire clamp for the syringes. The loose ends of the wire are bend outwards at the back of the baseboard.

7- METHOD OF USE

Having assembled the apparatus fill the syringes with water to approximately the half way position. Hold the plunger of the 50ml syringe and place a 50g. weight on the 10ml. syringe. Then place a 100g. weight on the 50ml. syringe which will be seen to rise when you remove your hand from holding the plunger.

8- COMMENTS

1- ITEM

HEAT CONVECTION APPARATUS.

2- PURPOSE

To investigate convection currents in air.

3- INFORMATION SUBMITTED BY

Pedagogical Academy, Nicosia, Cyprus.

4- LINE DRAWING OF PROTOTYPE

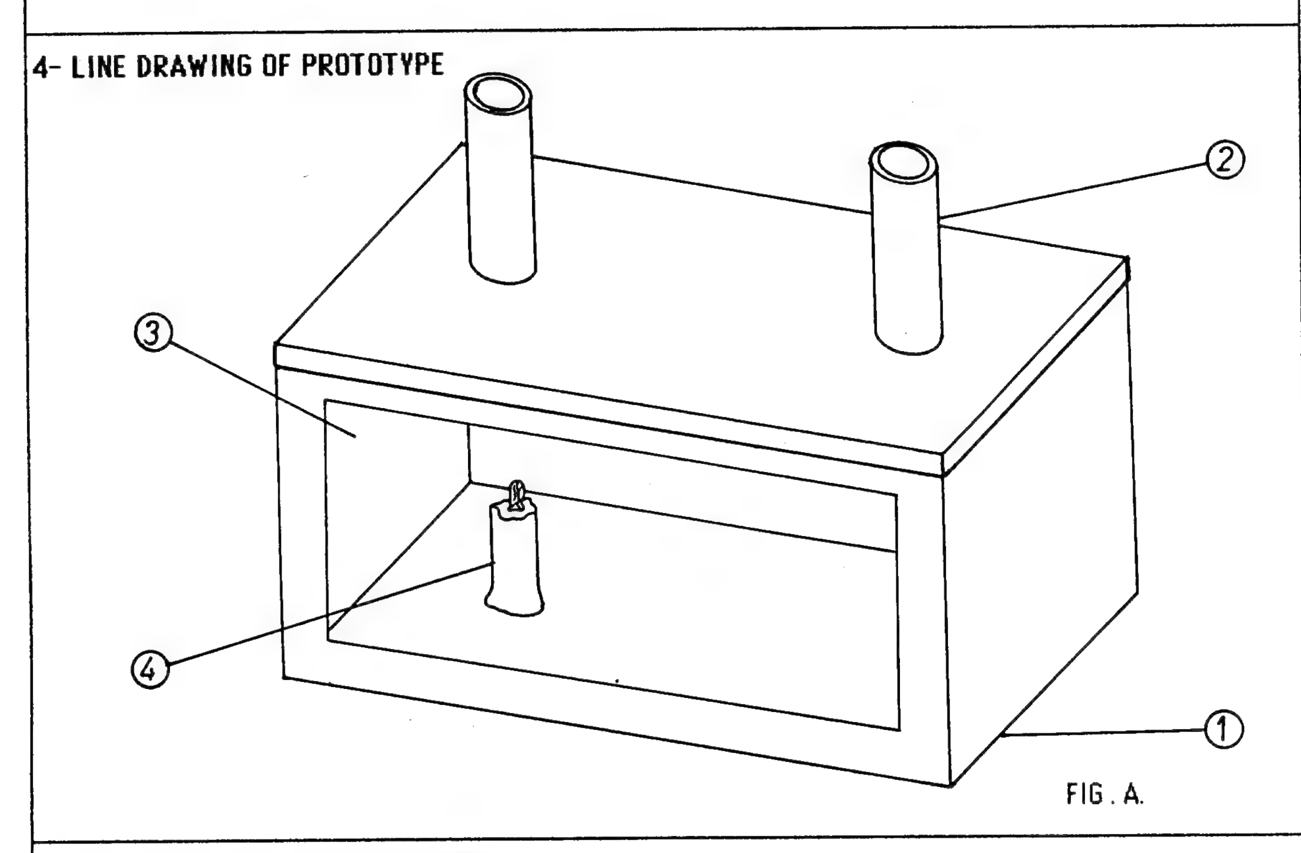


FIG. A.

5- MATERIALS FOR CONSTRUCTION

Components	Qty	Materials Required	Dimensions
1. Container.	1.	Cardboard Box.	300mm x 150mm x 100mm.
2. Chimneys.	2.	Glass tubes (or cardboard).	
3. Window.	1.	Glass or clear plastic sheet.	
4. Heat source.	1.	Small candle.	
		Plasticine.	
		Sellotape.	

Tools: Scissors.

6- CONSTRUCTION DETAILS

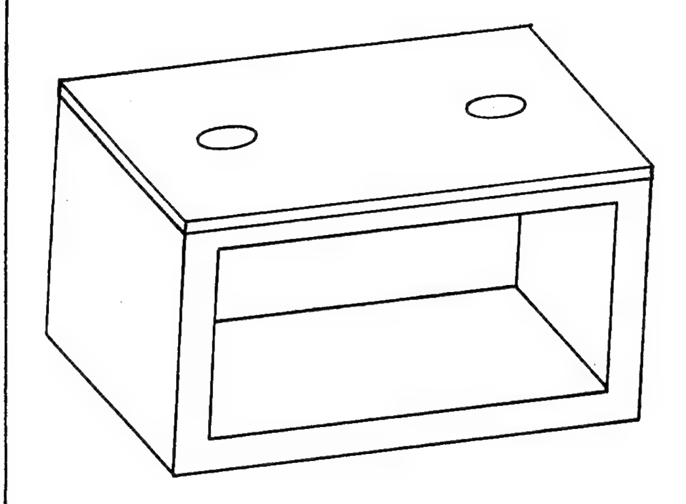


Fig. 1.

Obtain a large cardboard box and cut out a window as shown in Fig. 1. Cover this window with a sheet of glass or transparent plastic, using sellotape to hold it in place. In the lid of the box cut two holes to suit the diameter of the tube available.

Insert the tubes into the holes and fix them in place using plasticine.

7- METHOD OF USE

Remove the lid of the box and place a small candle under one of the two tubes. Fix it in place using plasticine. Light the candle and replace the lid on the box. Hold a smoldering taper over the top of the tube, opposite to the one above the candle. Observe the smoke in the box. Due to the convection currents in the air, brought about by the heat of the candle, the smoke will be seen to pass down one tube and go up through the other (which is above the candle).

8- COMMENTS

1- ITEM

HEAT ABSORPTION APPARATUS.

2- PURPOSE

To investigate the absorption of heat from the Sun by two different surfaces.

3- INFORMATION SUBMITTED BY

Pedagogical Academy, Nicosia, Cyprus.

4- LINE DRAWING OF PROTOTYPE

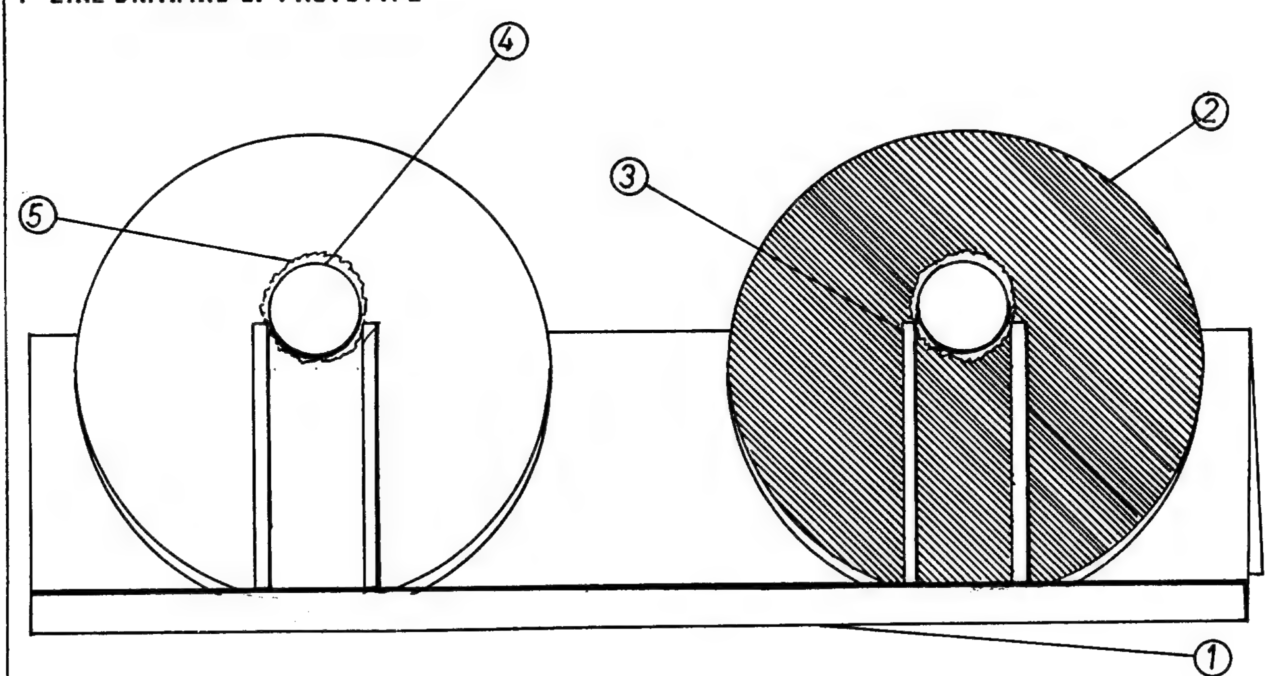


FIG. A.

5- MATERIALS FOR CONSTRUCTION

Components	Qty	Materials Required	Dimensions
1. Stand.	1.	Wood (or stiff cardboard).	600mm x 320mm x 3mm
2. Disc.	2.	Wood.	300mm dia.
3. Guides.	4.	Wood.	150mm x 6mm x 10mm
4. Sphere.	2.	Solid plastic ball.	approx. 10mm dia.
5. Jelly.		Petroleum Jelly (Vaseline)	
		White Paper.	
		Black paper.	

Tools: Woodsaw; hammer; small nails; scissors; adhesive.

6- CONSTRUCTION DETAILS

100mm
200mm
20mm

Fig. 1. Construct the stand from a piece of stiff cardboard as shown in Fig. 1. (alternatively 3mm plywood could be used).

10mm
150mm
6mm

Fig. 2. Construct four wooden guides each 150mm x 10mm x 6mm thick.

Construct two wooden discs of approx. 300mm dia. Glue a piece of white paper to one of the discs and a piece of black paper to the other. Fix two guides to each of the discs as shown in Fig. A. The distance between the two guides should be such that the ball can roll between them. Using petroleum jelly stick the two balls to the discs.

7- METHOD OF USE

Place the two discs on the stand and place the apparatus outside to face the Sun. Observe which of the two balls runs down between the guides first. This will demonstrate that, due to the black surface absorbing the heat radiated from the Sun at a greater rate than the white surface, the petroleum jelly melts first and releases the ball.

8- COMMENTS

1- ITEM

HEAT RADIATION APPARATUS.

2- PURPOSE

To demonstrate the radiation and absorption of heat by two different surfaces.

3- INFORMATION SUBMITTED BY

Beijing Teaching Aids Centre, Hengshui Prefecture, Hebei Province, China.

4- LINE DRAWING OF PROTOTYPE

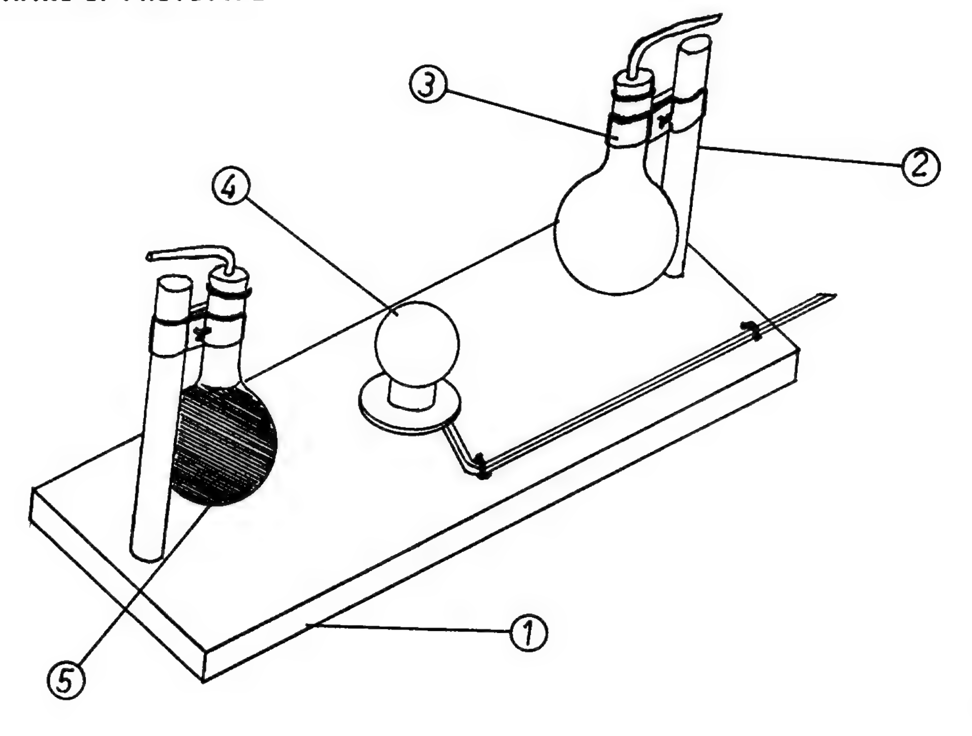


Fig. A.

5- MATERIALS FOR CONSTRUCTION

Components	Qty	Materials Required	Dimensions
1. Base.	1.	Plywood.	300mm x 170mm x 10mm
2. Support Rods.	2.	Wood Dowelling	150mm x 10mm dia.
3. Clamps.	2.	Metal Strip.	as available.
4. Heat Source.	1.	100 watt bulb and bulb holder.	
5. Vessels.	2.	Electric light bulbs (used).	
	2.	Corks.	To suit bulbs.
		Glass tube.	approx: 5mm o.d.
		Connecting cable and plug.	
		Black Ink.	

Tools: Wood saw, pliers, tin snips, cork borer, drill & drill bit, wood glue,

6- CONSTRUCTION DETAILS

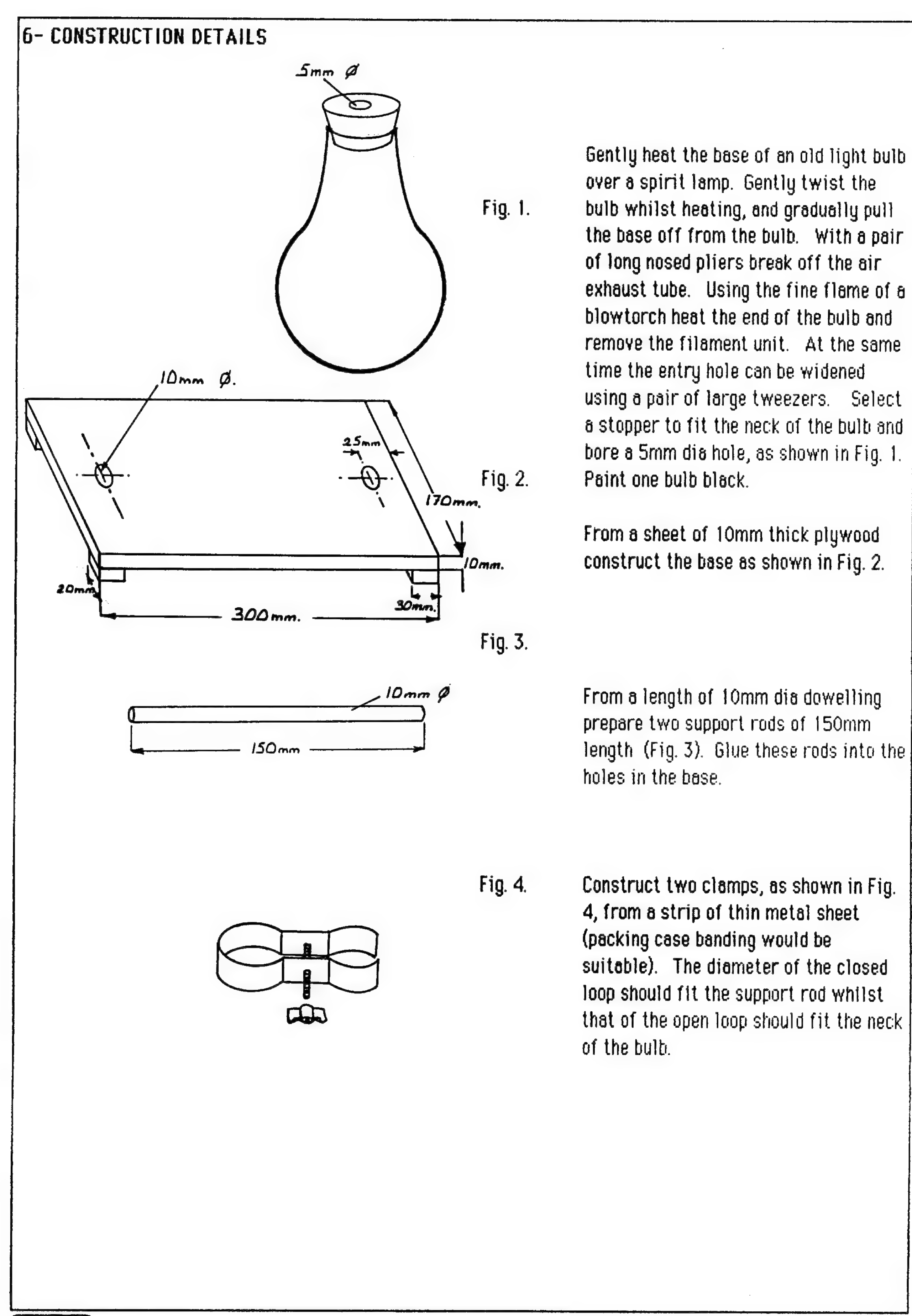


Fig. 1.

Gently heat the base of an old light bulb over a spirit lamp. Gently twist the bulb whilst heating, and gradually pull the base off from the bulb. With a pair of long nosed pliers break off the air exhaust tube. Using the fine flame of a blowtorch heat the end of the bulb and remove the filament unit. At the same time the entry hole can be widened using a pair of large tweezers. Select a stopper to fit the neck of the bulb and bore a 5mm dia hole, as shown in Fig. 1. Paint one bulb black.

Fig. 2.

From a sheet of 10mm thick plywood construct the base as shown in Fig. 2.

Fig. 3.

From a length of 10mm dia dowelling prepare two support rods of 150mm length (Fig. 3). Glue these rods into the holes in the base.

Fig. 4.

Construct two clamps, as shown in Fig. 4, from a strip of thin metal sheet (packing case banding would be suitable). The diameter of the closed loop should fit the support rod whilst that of the open loop should fit the neck of the bulb.

6- CONSTRUCTION DETAILS (Continued)

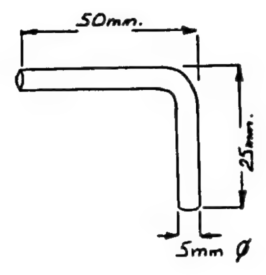


Fig. 5. From a length of 5mm dia glass tubing construct two right angled bends as shown in Fig. 5.

Assemble the apparatus as shown in Fig. A. and screw a bulb holder equi-distant between the two supports. Insert a 100 watt bulb.

7- METHOD OF USE

Pour water, mixed with red ink, into each of the two vessels. Switch on the 100 watt bulb (heater), and after a short period of time the water in the blackened bulb will be seen to be rising at a faster rate than that in the non painted bulb. This will show that radiated heat is absorbed quicker by a blackened surface.

8- COMMENTS

Wear eye protectors when working with glass. If a blowtorch is not available it may be possible to remove the whole of the cap end of the bulb by scoring a groove around the bulb, below the cap, with an old file.

1- ITEM

EXPANSION APPARATUS. (i)

2- PURPOSE

To demonstrate that a metal solid expands when heated.

3- INFORMATION SUBMITTED BY

Beijing Teaching Aids Centre, Hengshui Prefecture, Hebei Province, China.

4- LINE DRAWING OF PROTOTYPE

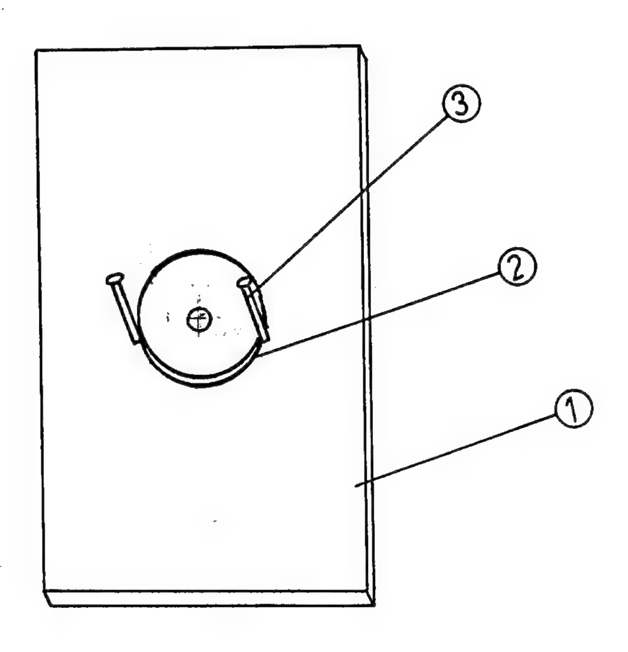


FIG. A.

5- MATERIALS FOR CONSTRUCTION

Components	Qty	Materials Required	Dimensions
1. Baseboard.	1.	Wood.	150mm x 100mm x10mm
2. Disc.	1.	Copper sheet.	20mm x 20mm x 0.3mm.
3. Spacers.	2.	Nails.	approx. 15mm long.
		Iron wire.	approx. 2mm dia.
		Spirit lamp.	

Tools: Woodsaw, hammer, tin snips, pliers

6- CONSTRUCTION DETAILS

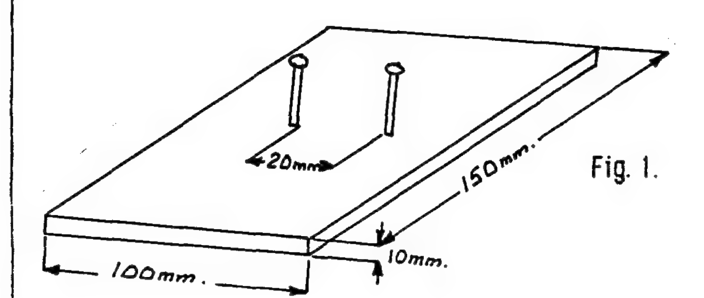


Fig. 1.

Construct a baseboard as shown in Fig. 1. Insert two nails, with a distance between them of 20mm.

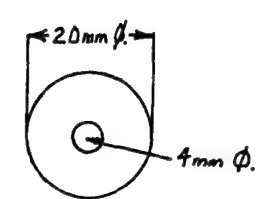


Fig. 2.

From a piece of copper sheet, of thickness 0.3mm, construct a washer of 20mm dia. as shown in Figure 2.
When the baseboard is raised the washer should just pass between the two nails.

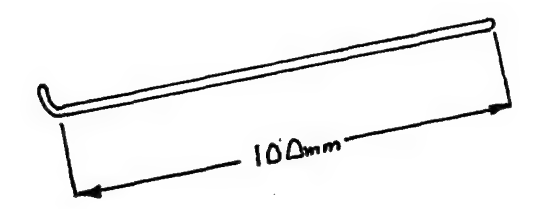


Fig. 3.

From a piece of stiff iron wire construct a hook for holding the copper washer whilst it is being heated.

7- METHOD OF USE

First demonstrate that the washer will pass through the gap between the nails. Then heat the washer over a spirit lamp and demonstrate that it will not pass between the nails. Allow the washer to cool and again show that it will pass between the nails.

8- COMMENTS

1- ITEM

EXPANSION APPARATUS. (ii)

2- PURPOSE

To demonstrate that air expands when heated.

3- INFORMATION SUBMITTED BY

Pedagogical Academy, Nicosia, Cyprus.

4- LINE DRAWING OF PROTOTYPE

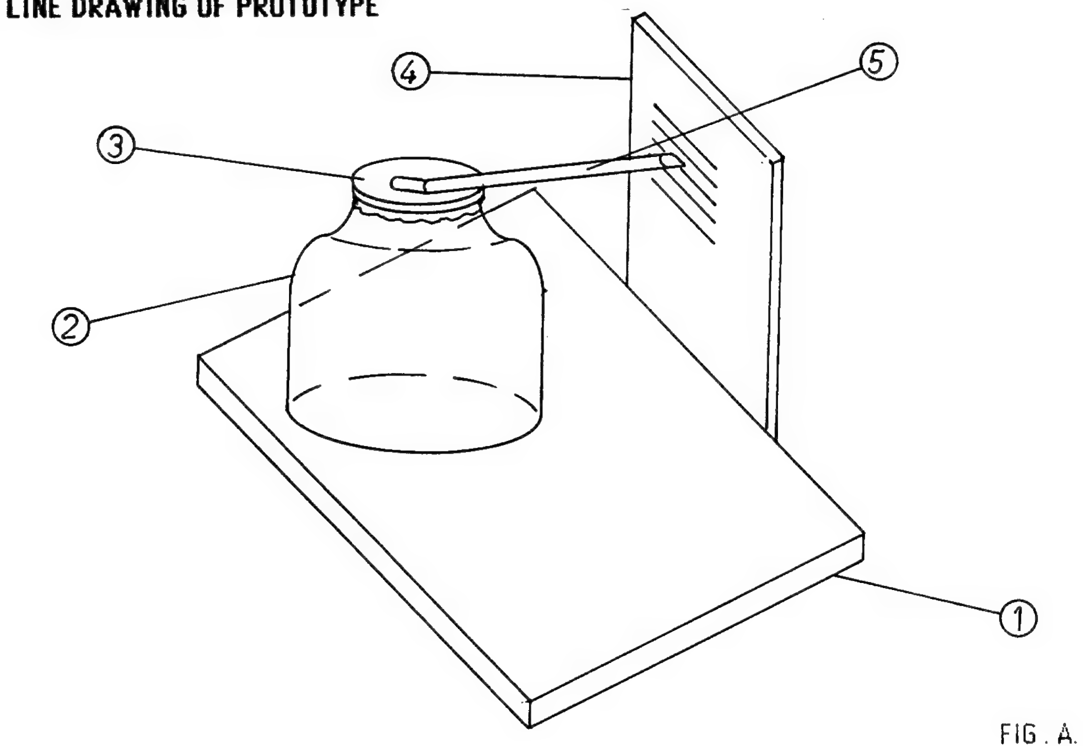


FIG. A.

5- MATERIALS FOR CONSTRUCTION

Components	Qty	Materials Required	Dimensions
1. Base.	1.	Wood.	200mm x 150mm x 10mm.
2. Container.	1.	Glass Jar, wide mouthed.	
3. Membrane.	1.	Thin Rubber (from a balloon).	
4. Indicator Board.	1.	Wood.	200mm x 100mm x 10mm.
5. Indicator.	1.	Straw. Rubber band. Adhesive.	

Tools: Woodsaw; hammer; nails; scissors

6- CONSTRUCTION DETAILS

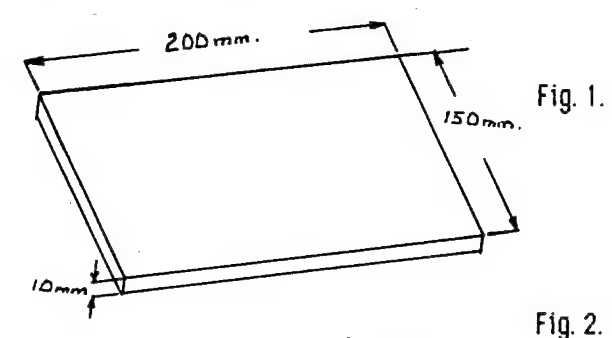


Fig. 1. Construct the base from a piece of 10mm plywood as shown in Fig. 1.

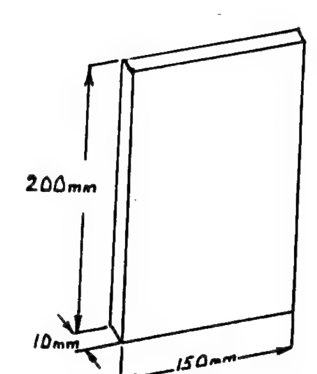


Fig. 2. Construct the indicator board as shown in Fig. 2. Nail and glue the board centrally to one edge of the base.
Glue the sheet of white paper to the face of the indicator board.

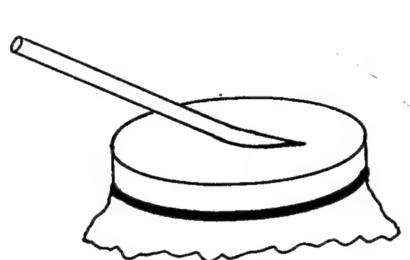


Fig. 3. Stretch the rubber across the mouth of the bottle and hold in place using a rubber band. Flatten one end of a straw and glue the straw to the rubber, as shown in Fig. 3.

7- METHOD OF USE

Adjust the bottle on the base so that the indicator is close to the indicator board. Mark the position of the top of the indicator on the paper. Carefully place the apparatus in direct sunlight and observe the movement of the indicator. The air trapped in the jar expands and pushes the rubber membrane upwards as can be seen by the movement of the indicator.

8- COMMENTS

The indicator board could consist of a piece of stiff cardboard if a simple arrangement was all that was required.

1- ITEM

A CONDENSER.

2- PURPOSE

For condensing vapour to a liquid.

3- INFORMATION SUBMITTED BY

Beijing Teaching Aids Centre, Hengshui Prefecture, Hebei Province, China.

4- LINE DRAWING OF PROTOTYPE

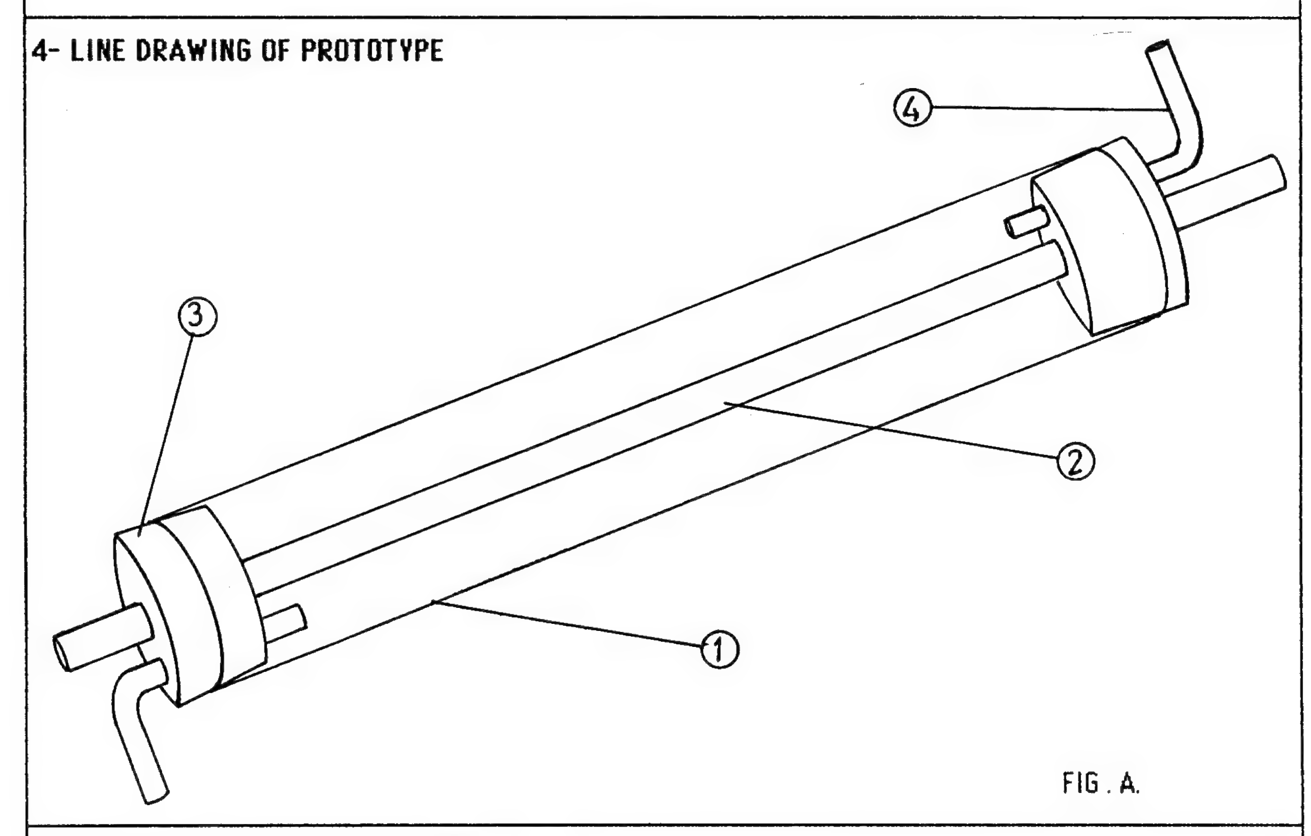


FIG . A.

5- MATERIALS FOR CONSTRUCTION

Components	Qty	Materials Required	Dimensions
1. Outer tube.	1.	Flourescent Lamp Glass Tube	approx. 400mm.
2. Inner tube.	1.	Glass Tube.	8mm o.d. x 500mm.
3. Stoppers.	2.	Rubber stoppers.	to suit outer tube
4. Cooling water tubes	2.	Glass tube.	5mm o.d. x 100mm.

Tools: Glass cutter (or old file), cork borers.

6- CONSTRUCTION DETAILS

From a useless flourescent lamp of approximately 40mm dia. cut a 400mm length of tube. Carefully remove the sharp edges and then clean the inside of the tube.

Obtain a length of 8mm outside diameter glass tubing and cut it to a length of 500mm. Remove the sharp edges.

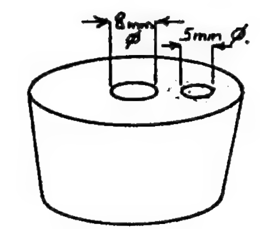


Fig. 1. Take two rubber stoppers suitable in diameter for the fluorescent tube. Through the centre of each stopper bore an 8mm dia. hole. At a suitable distance from this hole bore a second hole of 5mm dia as shown in Fig. 1.

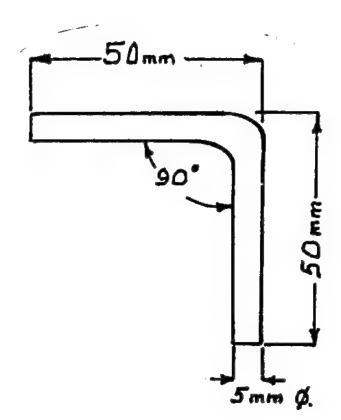


Fig. 2. Obtain a length of 5mm outside diameter glass tubing and cut two lengths of 100mm. Bend both tubes into a right angle as shown in Fig. 2.

Assemble the apparatus as shown in Fig. A. taking extreme care when inserting the stoppers into the fragile outer glass tube. Seal the stoppers to the glass with a suitable adhesive or sealant

7- METHOD OF USE

Use in the same manner as a commercially manufactured condenser.

8- COMMENTS

Wear eye protection when working with glass. Handle the old fluorescent tube carefully since the glass is fragile and can break easily. Very old fluorescent lamps contained a toxic coating on the interior. Wash away all residue when cleaning the interior of the tube.

1- ITEM

FUEL COMPARISON APPARATUS.

2- PURPOSE

To compare the rate of burning of two different fuels.

3- INFORMATION SUBMITTED BY

Pedagogical Academy, Nicosia, Cyprus.

4- LINE DRAWING OF PROTOTYPE

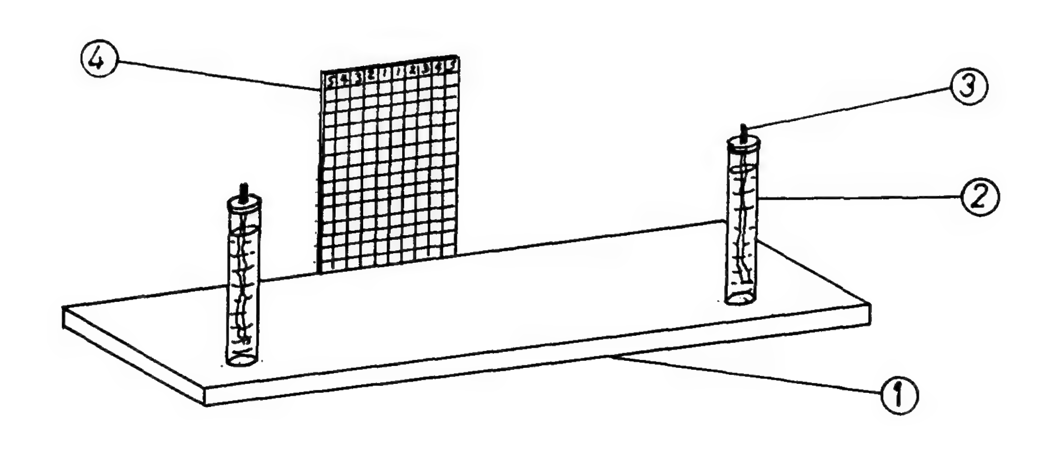


FIG. A.

5- MATERIALS FOR CONSTRUCTION

Components	Qty	Materials Required	Dimensions
1. Base.	1	Wood.	300mm x 150mm x 10mm.
2. Containers.	2	Glass tube with caps.	approx. 10mm dia x 50mm.
3. Wick.	2	Twisted cotton.	
4. Indicator Board.	1	Wood. Plasticine. White squared paper.	100mm x 150mm x 5mm.

Tools: hammer; nails; woodsaw.

6- CONSTRUCTION DETAILS

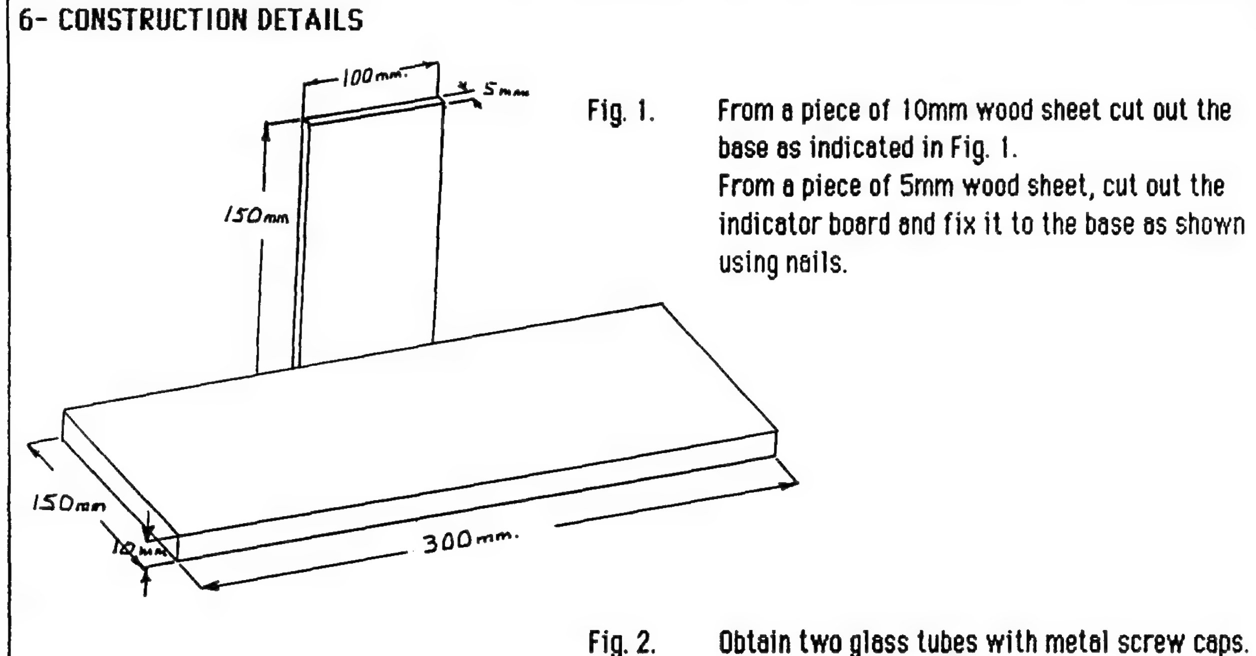


Fig. 1. From a piece of 10mm wood sheet cut out the base as indicated in Fig. 1.
From a piece of 5mm wood sheet, cut out the indicator board and fix it to the base as shown using nails.

Fig. 2. Obtain two glass tubes with metal screw caps. Pierce a hole to take the wick in each of the two caps. Make two wicks from twisted cotton (or string) and feed the wicks through the holes in the lids as shown in Fig. 2.

50mm.

10mm Ø.

Assemble the apparatus by placing the tubes on to the base and fix in place using plasticine.
Fix a piece of graph paper to the indicator board as shown in Fig. A.

7- METHOD OF USE

Pour equal quantities of the two fuels to be compared into the two tubes, insert the wicks, and screw down the lids. Allow the wicks to become saturated. Light both wicks simultaneously and observe the level of the fuel in each tube at one minute intervals. Mark on the paper how many mm of fuel are burnt for each period of observation.

8- COMMENTS

1- ITEM

ELECTROLYSIS OF SALT WATER APPARATUS.

2- PURPOSE

To produce NaOH using an egg shell as a membrane.

3- INFORMATION SUBMITTED BY

Beijing Teaching Aids Centre, Hengshui Prefecture, Hebei Province, China.

4- LINE DRAWING OF PROTOTYPE

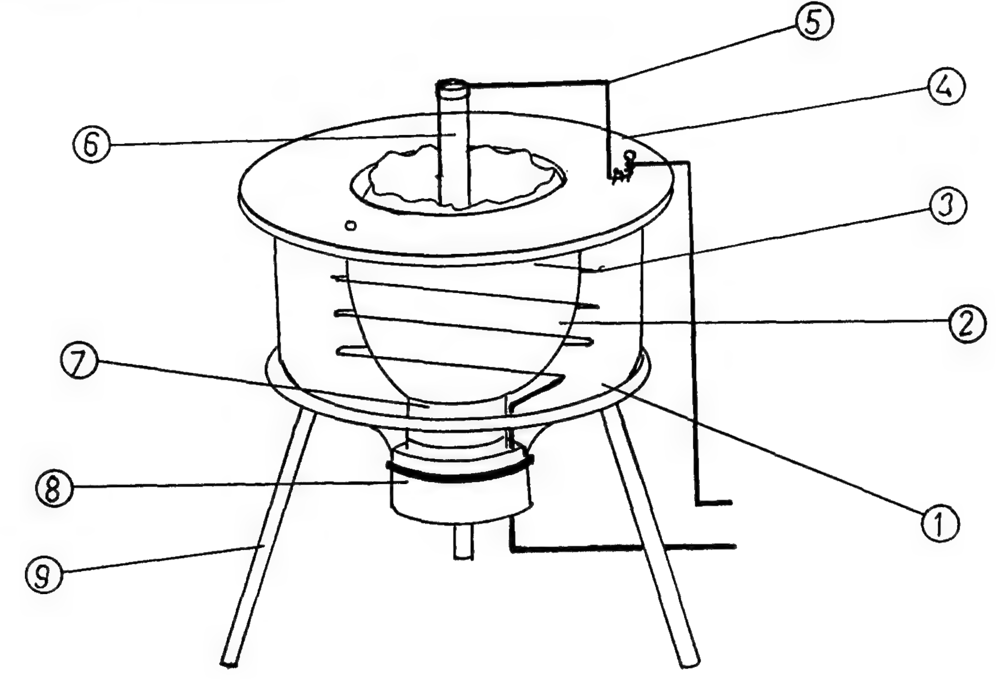


FIG . A.

5- MATERIALS FOR CONSTRUCTION

Components	Qty	Materials Required	Dimensions
1. Container.	1.	Glass Bottle, wide mouthed.	as available.
2. Membrane.	1.	Egg shell.	
3. Coil.	1.	Iron wire.	2.5mm dia x 300mm
4. Lid.	1.	Plywood.	as available.
5. Connecting Leads.	2.	Copper wire (stiff)	approx. 2mm dia. x 150mm
6. Carbon rod.	1.	Carbon rod from old battery.	
7. Eggshell stand.	1.	Ink bottle lid.	as available.
8. Stopper.	1.	Rubber stopper.	to suit bottle
9. Stand.	1.	Tripod.	as available.
		Paraffin Wax.	
		Nails.	
		Tools: Glass cutter, knife, pliers, soldering iron, woodsaw, hammer.	

6- CONSTRUCTION DETAILS

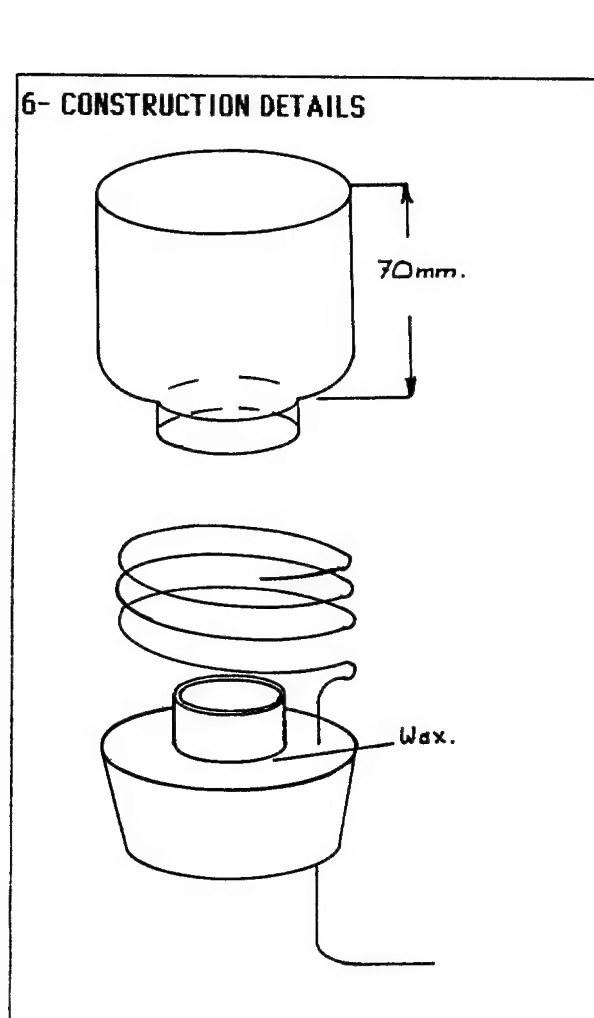


Fig. 1.

Obtain a wide mouthed bottle and cut the bottom off at approximately 70mm from the neck as shown in Fig. 1.

Obtain a stopper to fit the mouth of the bottle and make a small hole to take the iron wire, as shown in Fig. 2. Pass the wire through the hole and make a coil of three turns. The diameter of the coil should be just larger than the dia. of the egg. Obtain an ink bottle lid (to act as an "egg cup") and fix it to the stopper with paraffin wax. Fit the stopper into the bottle.

Fig. 2.

Make a hole of approximately 15mm diameter in one end of the egg. Empty out the egg and wash the inside clean. Stand the empty egg shell on the cup with the hole uppermost.

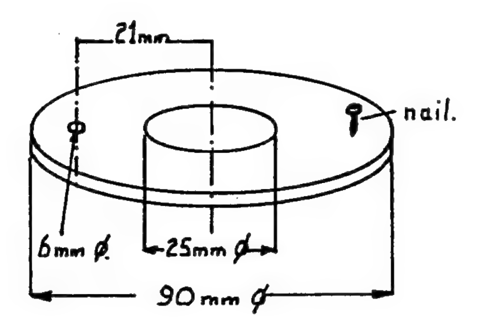


Fig. 3.

Construct a lid for the bottle as shown in Fig. 3. The actual dimensions will depend upon the size of the bottle being used.

Solder a length of iron wire to the metal cap of a carbon rod obtained from an old dry cell (torch battery). Fix the iron wire to the lid in such a way that the carbon rod is suspended through the centre hole in the lid and can protrude down into the egg shell. The rod should not be able to touch the shell. Having connected the iron wire to the lid using nails attach a length of copper connecting lead to a nail; also connect a length to the iron wire protruding out from underneath the stopper. Finally stand the apparatus on a tripod as shown in Fig. A.

7- METHOD OF USE

Pour some salt water into the eggshell and into the bottle. Connect the leads to a 6 volt electrical supply and switch on. After some minutes gas bubbles will appear on the carbon rod and on the iron wire coil. After several minutes leave a piece of KI-amylum test paper over the small hole in the lid, and another piece over the hole in the eggshell top. The piece over the eggshell will change colour from white to blue whilst that over the small hole will be unchanged. Switch off the power and introduce a few drops of phenolphthalein solution into both the eggshell and the bottle. The solution in the bottle will change its colour to red but the solution in the eggshell will not change colour. If the students know the properties of the KI-amylum test paper and the phenolphthalein solution they can deduce what has occurred during the experiment.

8- COMMENTS

1- ITEM

SUN, MOON, AND EARTH APPARATUS.

2- PURPOSE

To demonstrate the Earth revolving around the Sun and the Moon revolving around the Earth.

3- INFORMATION SUBMITTED BY

Pedagogical Academy, Nicosia, Cyprus.

4- LINE DRAWING OF PROTOTYPE

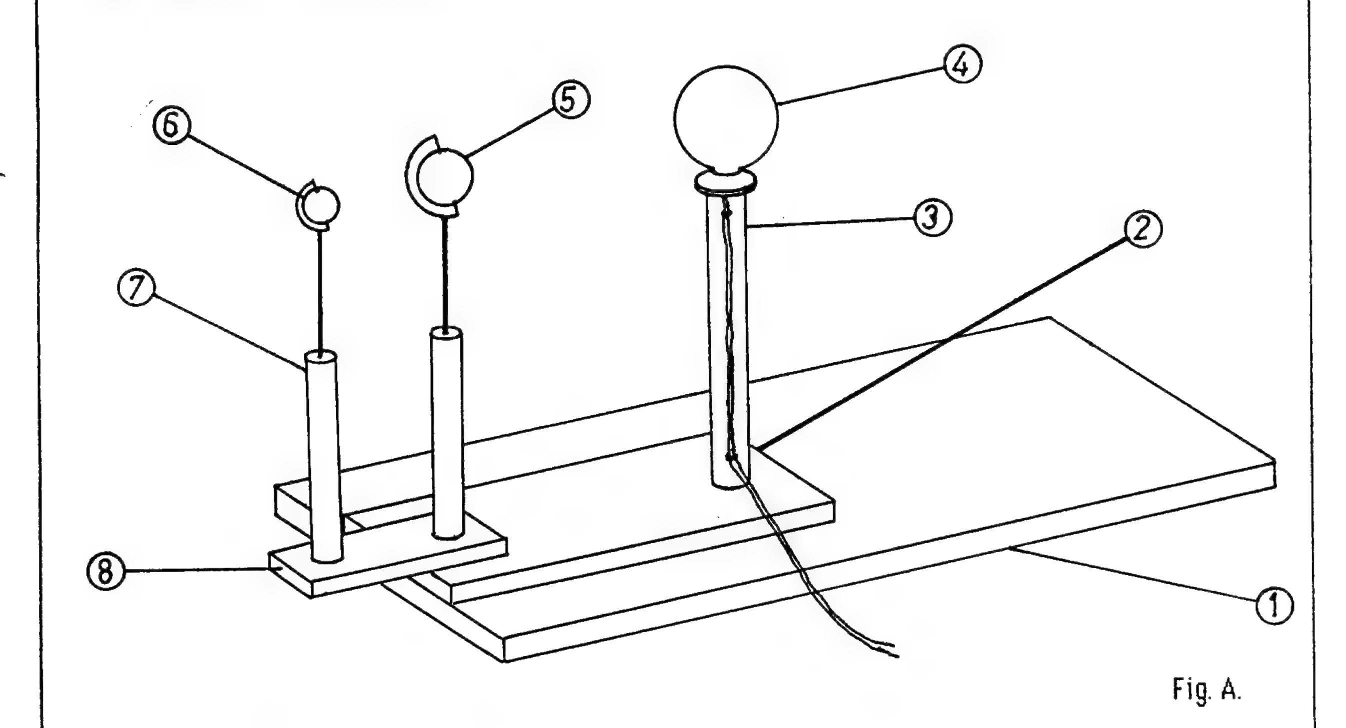


Fig. A.

5- MATERIALS FOR CONSTRUCTION

Components	Qty	Materials Required	Dimensions
1. Base.	1.	Wood.	1000mm x200mm x 10mm.
2. Movable Arm (1).	1.	Wood.	400mm x 100mm x 10mm.
3. Support Rod.	1.	Wood.	350mm x 20mm dia.
4. Sun.	1.	Bulb and bulb holder and white globe (150mm dia).	
5. Earth.	1.	Wooden Ball.	approx. 50mm dia.
6. Moon.	1.	Wooden Ball.	approx. 20mm dia.
7. Support Rods.	2.	Wood(and iron wire).	250mm x 10mm dia.
8. Movable Arm (2).	1.	Wood.	150mm x 80mm x 10mm.
		Adhesive.	
		Electric cable.	approx. 1 metre.
		Stiff metal wire.	
		Tools: Woodsaw; drill and drill bits; long nosed pliers.	

6- CONSTRUCTION DETAILS

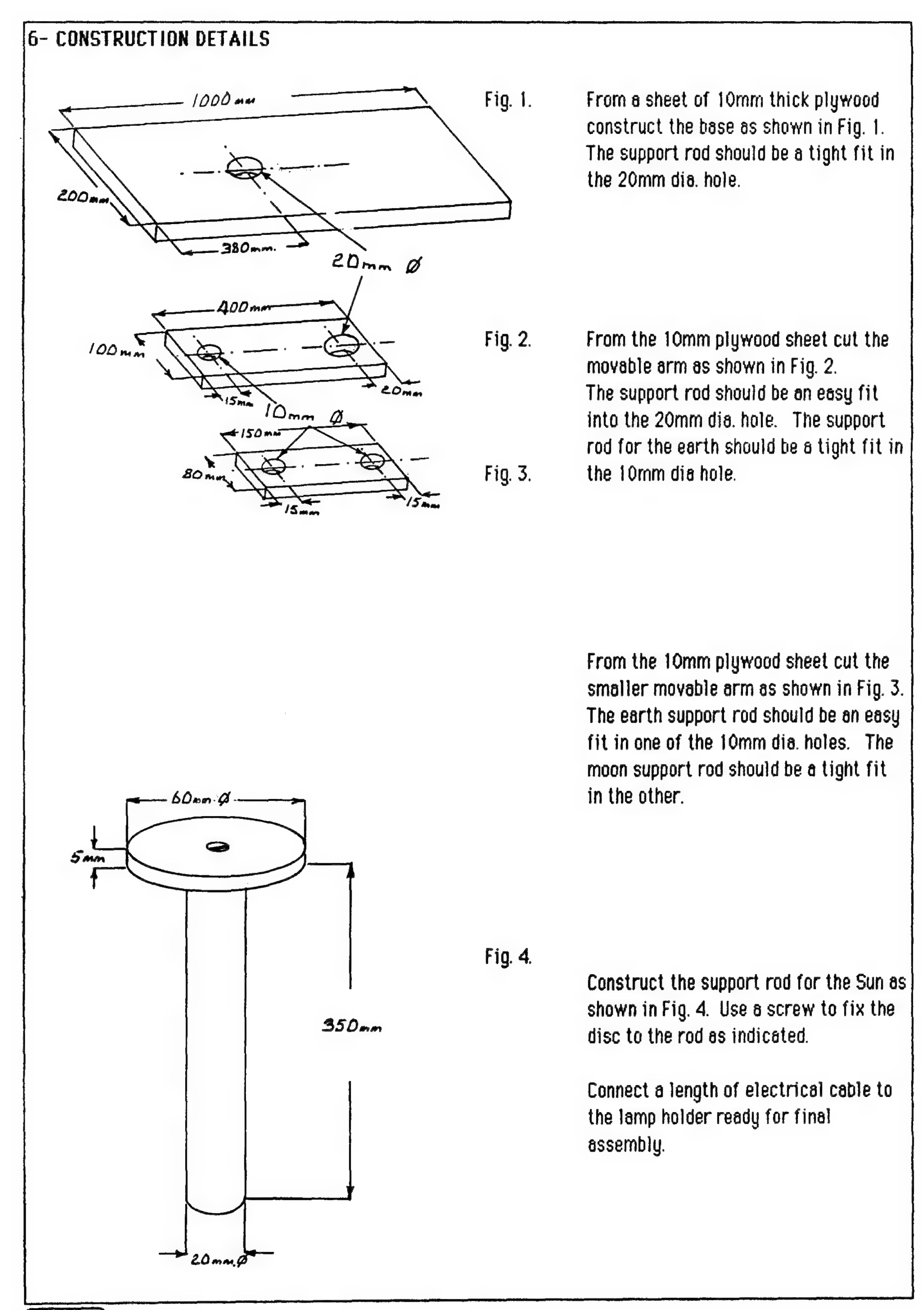


Fig. 1.

From a sheet of 10mm thick plywood construct the base as shown in Fig. 1. The support rod should be a tight fit in the 20mm dia. hole.

Fig. 2.

From the 10mm plywood sheet cut the movable arm as shown in Fig. 2. The support rod should be an easy fit into the 20mm dia. hole. The support rod for the earth should be a tight fit in the 10mm dia hole.

Fig. 3.

From the 10mm plywood sheet cut the smaller movable arm as shown in Fig. 3. The earth support rod should be an easy fit in one of the 10mm dia. holes. The moon support rod should be a tight fit in the other.

Fig. 4.

Construct the support rod for the Sun as shown in Fig. 4. Use a screw to fix the disc to the rod as indicated.

Connect a length of electrical cable to the lamp holder ready for final assembly.

6- CONSTRUCTION DETAILS (Continued)

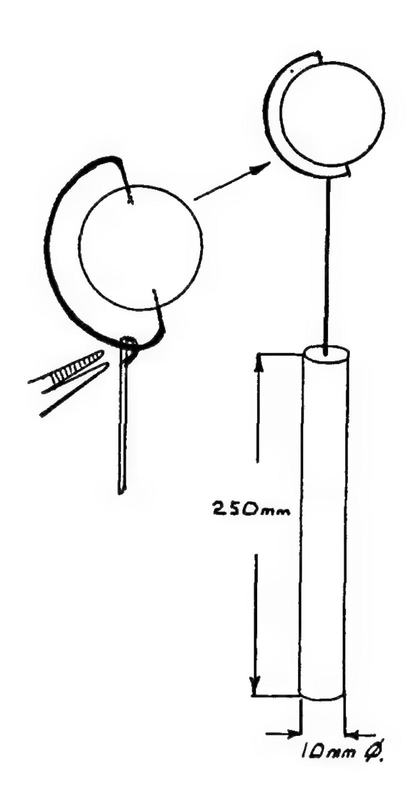


Fig. 5. From a piece of 10mm dia wooden doweling cut two pieces each 250mm long. Drill a small hole in the end for inserting metal wire available. Drill two small holes diagonally opposite each other in the two wooden balls to be used as the Earth and the Moon. Bend a suitable length of wire as in Fig. 5. to act as the axis and support for the balls Make one for each ball.Take a straight length of stiff wire and bend one end over the ball support as in the sketch. Crimp this loop tightly over the support using long nose pliers, (this joint could be soldered if steel or copper wire is used). Leave the length of straight wire uncut until final assembly. Assemble the apparatus by gluing the support for the Sun in the hole in the base. Slide movable arm (i) over the support and ensure that it will rotate. Screw lamp support disc to the top of the column and then fix the lamp holder to this disc Glue Earth support rod into the 10mm hole in the moveable arm (1). Slide moveable arm (2) over this column and ensure that it will rotate. Glue support rod for Moon in second hole. Finally insert Earth and Moon assemblies into respective supports. (Ensure that the centres of the Sun, Earth and Moon are all in the same horizontal plane).

7- METHOD OF USE

Switch on the lamp and demonstrate the rotation of the Earth around the Sun; the Moon around the Earth; or the Earth around its own axis.

8- COMMENTS

1- ITEM

LAW OF REFLECTION APPARATUS.

2- PURPOSE

To investigate the relationship between the angles of incidence and reflection.

3- INFORMATION SUBMITTED BY

Pedagogical Academy, Nicosia, Cyprus.

4- LINE DRAWING OF PROTOTYPE

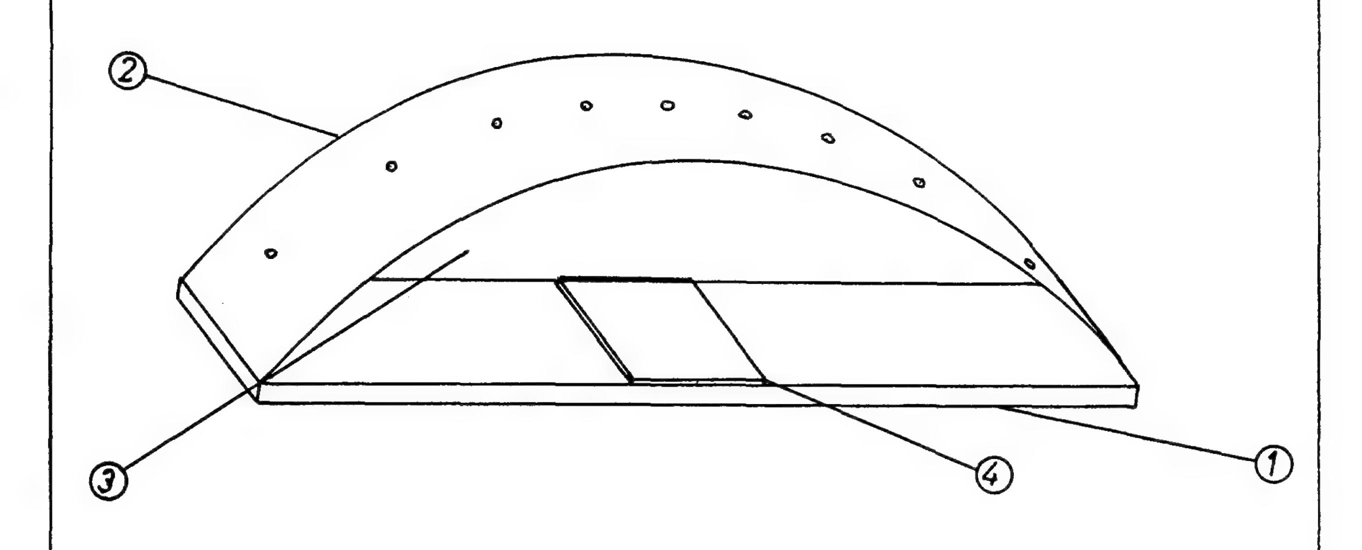


FIG. A.

5- MATERIALS FOR CONSTRUCTION

Components	Qty	Materials Required	Dimensions
1. Base.	1.	Wood.	400mm x 100mm x 10mm.
2. Cover.	1.	Cardboard.	approx. 650mm long.
3. Back Plate.	1.	Cardboard.	approx. 400mm dia.
4. Mirror.	1.	Mirror.	approx. 100mm x 60mm.
		Drawing pins.	
		Adhesive.	

Tools: Woodsaw; scissors.

6- CONSTRUCTION DETAILS

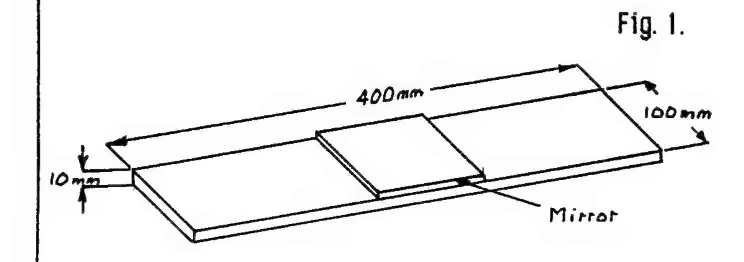


Fig. 1.

Construct the base from a piece of 10mm plywood. Glue a small mirror to the centre of the base as shown in Fig. 1.

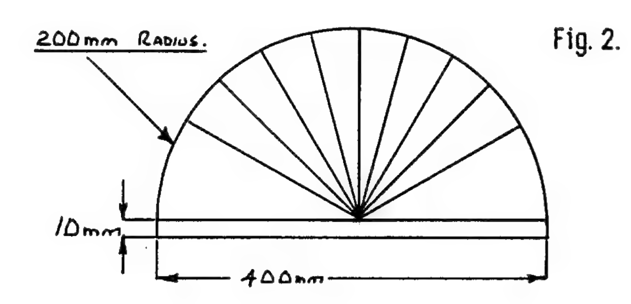


Fig. 2.

From a sheet of stiff cardboad cut out a semi-circular back plate as shown in Fig. 2. Mark lines on the back plate at 15° intervals either side of the vertical.

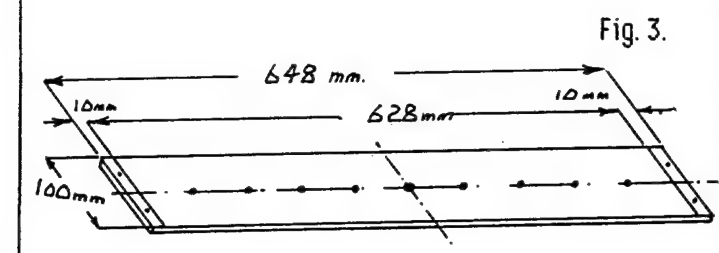


Fig. 3.

From a sheet of stiff cardboard cut out the cover as shown in Fig. 3. Using drawing pins, fix the cover to the ends of the base; this will form a semi-circle to match the perimeter of the back plate. Pierce holes in the cover to co-incide with the lines on the back plate.

7- METHOD OF USE

Place a light source (candle or lamp) at one of the holes and view through a hole opposite to the one with the lamp to see if the light is being reflected via the mirror. Measure the angles of the lines drawn on the back plate to see if the Law of Reflection is applicable (Angle of Incidence is equal to the Angle of Reflection).

8- COMMENTS

An alternative method would be to leave the back plate unmarked and pierce holes in the cover at regular intervals. Using a light source at one hole find the opposite hole where the light is reflected and then draw lines on the back plate. The angles could then be measured.

1- ITEM

REFRACTION OF LIGHT APPARATUS.

2- PURPOSE

To demonstrate refraction of light in water.

3- INFORMATION SUBMITTED BY

Beijing Teaching Aids Centre, Hengshui Prefecture, Hebei Province, China.

4- LINE DRAWING OF PROTOTYPE

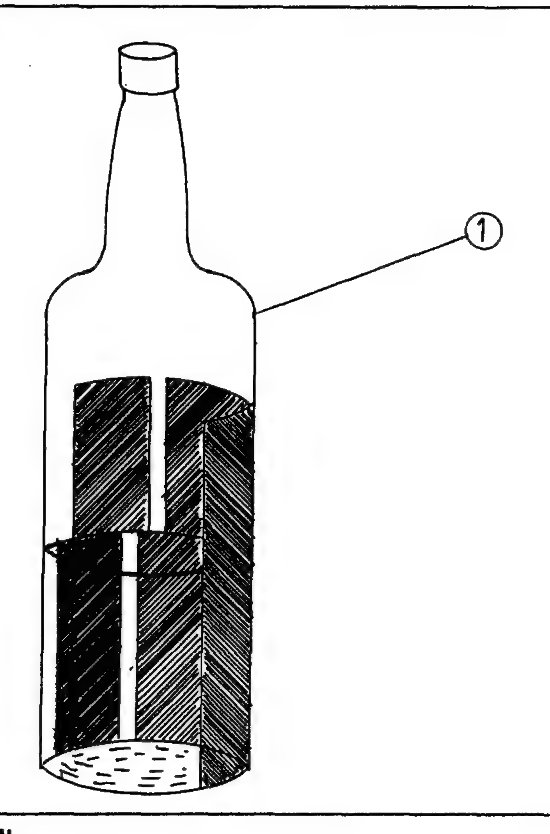


FIG. A.

5- MATERIALS FOR CONSTRUCTION

Components	Qty	Materials Required	Dimensions
1. Bottle	1.	Glass Bottle. Black paint (or ink).	as available.

6- CONSTRUCTION DETAILS

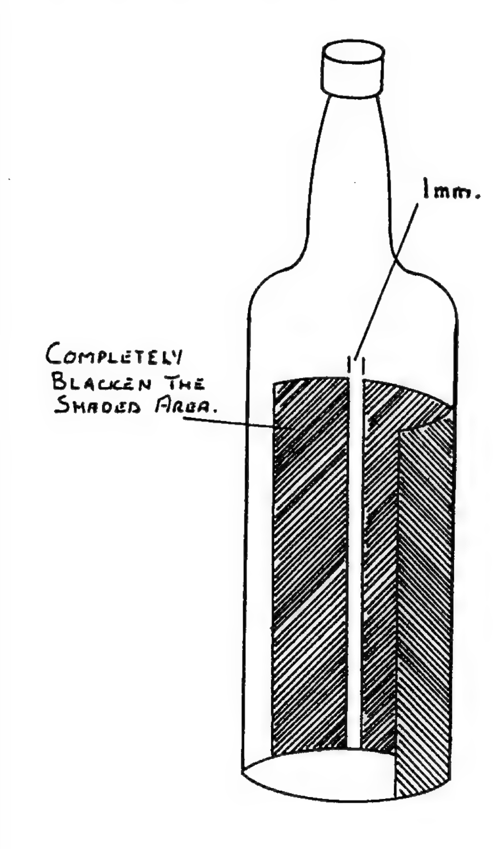


Fig. 1.

Using an empty, clear bottle paint half of the outside of the bottle with black paint, leaving a gap of approximately 1 to 2 mm as shown in Figure 1.

7- METHOD OF USE

Fill the bottle with water to half way up the black painted area. Observe the gap in the black painted area which will appear displaced when looking into the water. This clearly demonstrates light refraction in water.

8- COMMENTS

When viewing from the front ensure that the brightest light intensity is behind the black painted surface. If necessary use a shield to reduce stray light.

1- ITEM

A CONVEX WATER LENS (i)

2- PURPOSE

To construct a convex water lens for simple optical experiments.

3- INFORMATION SUBMITTED BY

Beijing Teaching Aids Centre, Hengshui Prefecture, Hebei Province, China.

4- LINE DRAWING OF PROTOTYPE

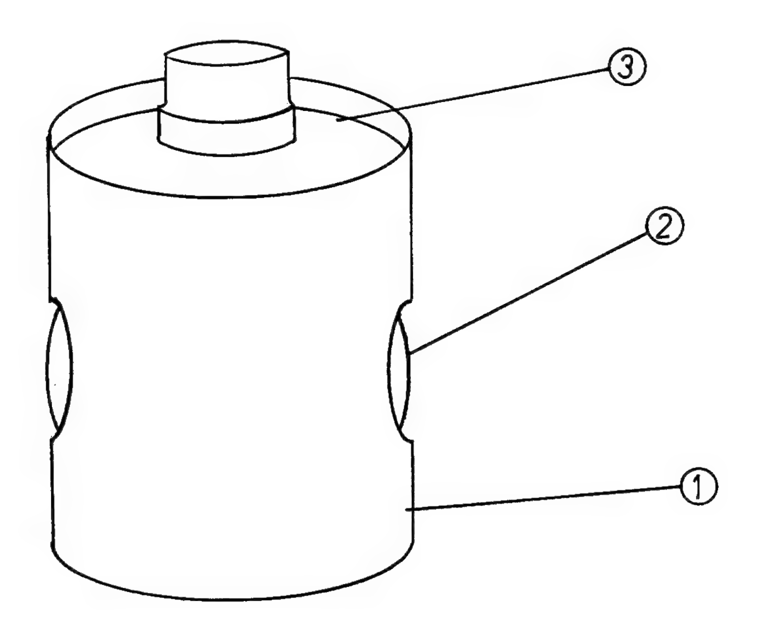


Fig. A.

5- MATERIALS FOR CONSTRUCTION

Components	Qty	Materials Required	Dimensions
1. Aperture Cylinder.	1.	Cardboard.	approx. 25cm x 15cm.
2. Water Container.	1.	Electrical light bulb.	as available.
3. Centralising Ring.	1.	Cardboard.	to suite dia. of bulb.
	1.	Cardboard.	approx. 20cm x 20cm
		Adhesive.	

Tools: Scissors, long-nosed pliers, spirit burner.

6- CONSTRUCTION DETAILS

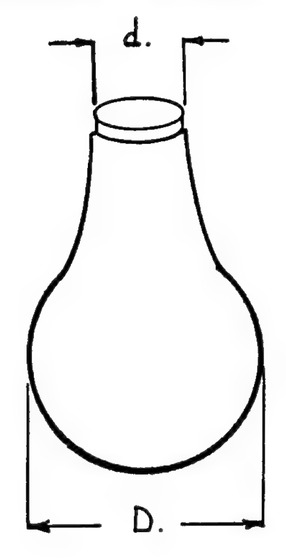


Fig. 1.

Gently heat the base of an old bulb over a spirit lamp. Gently twist the bulb whilst heating and gradually pull the base off from the bulb. With a pair of long nose pliers break off the air exhaust tube. Using the fine flame of a blow torch heat the end of the bulb and remove the filament unit. At the same time the entry hole can be widened using a pair of large tweezers.

Let D = diameter of bulb.
d = diameter of bulb neck.

See Fig. 1

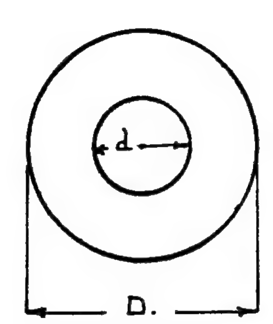


Fig. 2.

From a piece of cardboard cut out a centralising ring of outer diameter D. and inner diameter d. as in Fig. 2.

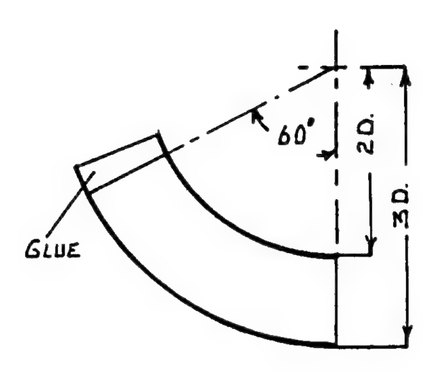


Fig. 3.

On a piece of cardboard mark out the shape shown in Fig. 3. Allow a little over 60°, for gluing purposes. Cut out and glue the shape to form a truncated cone stand for the bulb.

6- CONSTRUCTION DETAILS (Continued)

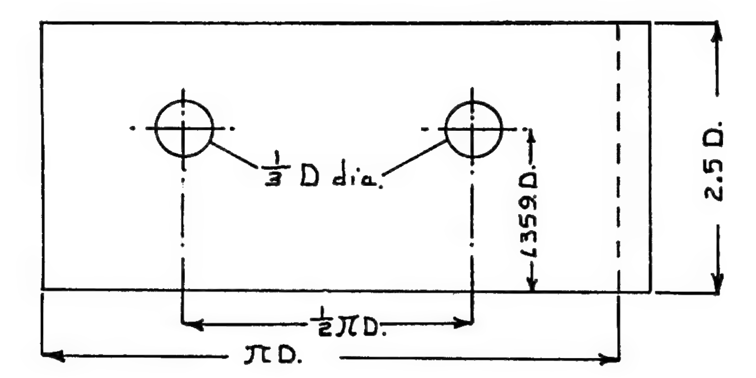


Fig. 4.

On a piece of cardboard mark out a rectangle D long and 2.5D wide. (Allow a little extra on the length for gluing purposes). Mark out two holes each of 1/3 D in diameter, according to the dimensions given in Fig. 4. Cut out the holes and the rectangle. Bend and glue the rectangle to form the aperture cylinder.

Assemble the apparatus by placing the stand on the desk and the bulb on the stand. Then place the aperture cylinder over the bulb with one hole facing an object (e.g. the window). Place the centralising ring over the neck of the bulb to hold it steady. Finally fill the bulb with water.

7- METHOD OF USE

Set the apparatus on the desk with an unpainted face towards the window. Fill the bulb with water. Using a notebook as a screen adjust the distance of the notebook from the lens until a clear upside down image of the window can be seen (objects outside the window may also be able to be focussed onto the screen).

8- COMMENTS

Wear eye protectors when working with glass. If a blow torch is not available it may be possible to remove the whole of the cap end of the bulb by scoring a groove around the bulb, below the cap, with an old file.

1- ITEM

A CONVEX WATER LENS. (ii).

2- PURPOSE

To construct a convex water lens for simple optical experiments.

3- INFORMATION SUBMITTED BY

Beijing Teaching Aids Centre, Hengshui Prefecture, Hebei Province, China.

4- LINE DRAWING OF PROTOTYPE

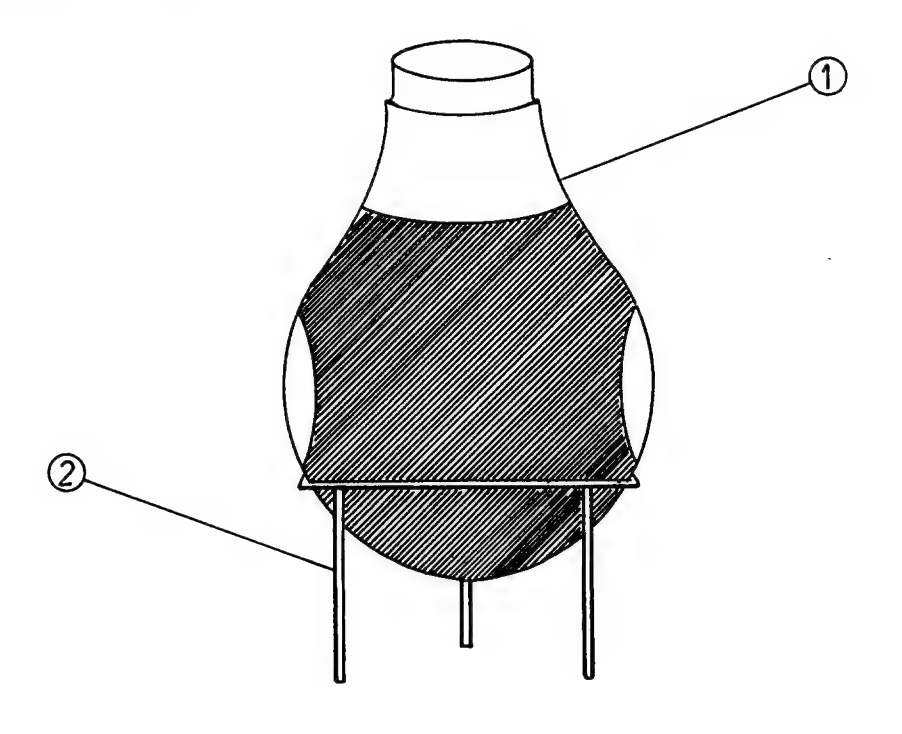


FIG. A.

5- MATERIALS FOR CONSTRUCTION

Components	Qty	Materials Required	Dimensions
1. Water container.	1.	Electric Light Bulb.	as available.
2. Stand.	1.	Iron Wire.	2mm dia. x 500mm
		Black Paint.	

Tools: Long-nosed pliers, spirit burner.

6- CONSTRUCTION DETAILS

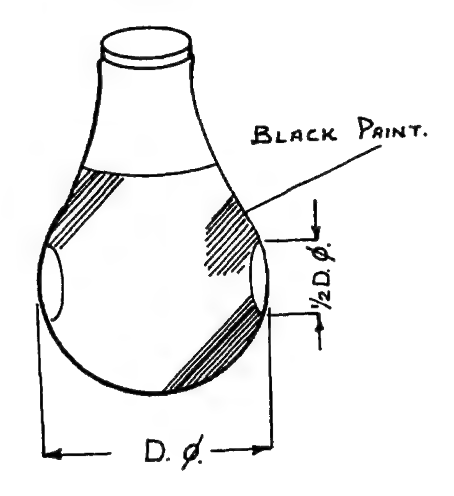


Fig. 1.

Gently heat the base of an old bulb over a spirit burner. Gently twist the bulb whilst heating and gradually pull the base off from the bulb. With a pair of long nose pliers break off the air exhaust tube. Using the fine flame of a blow lamp heat the end of the bulb and gradually remove the filament unit. At the same time the entry hole can be widened using a pair of large tweezers.

Paint the bulb black leaving two "windows" which should be diametrically opposite each other. The diameter of the "windows" should be approximately 1/2 the diameter of the bulb. (Fig. 1.).

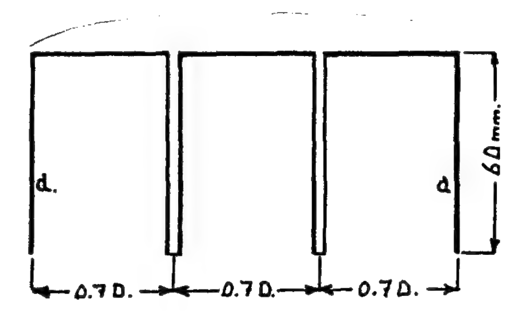


Fig. 2.

From a length of stiff iron wire construct a stand for the bulb as shown in Fig. 2. Bend the frame so that the legs marked "a" meet to form a tripod.

7- METHOD OF USE

Set the apparatus on the desk with an unpainted face towards the window. Fill the bulb with water. Using a notebook as a screen adjust the distance of the notebook from the lens until a clear upside down image of the window can be seen (objects outside the window may also be able to be focussed onto the screen).

8- COMMENTS

Wear eye protectors when working with glass. If a blowlamp is not available it may be possible to remove the whole of the cap end of the bulb by scoring a groove around the bulb, below the cap, with an old file.

1- ITEM

ELECTRICAL CONDUCTANCE APPARATUS.

2- PURPOSE

To investigate which solid materials are good conductors of electricity, and which are good insulators.

3- INFORMATION SUBMITTED BY

Pedagogical Academy, Nicosia, Cyprus.

4- LINE DRAWING OF PROTOTYPE

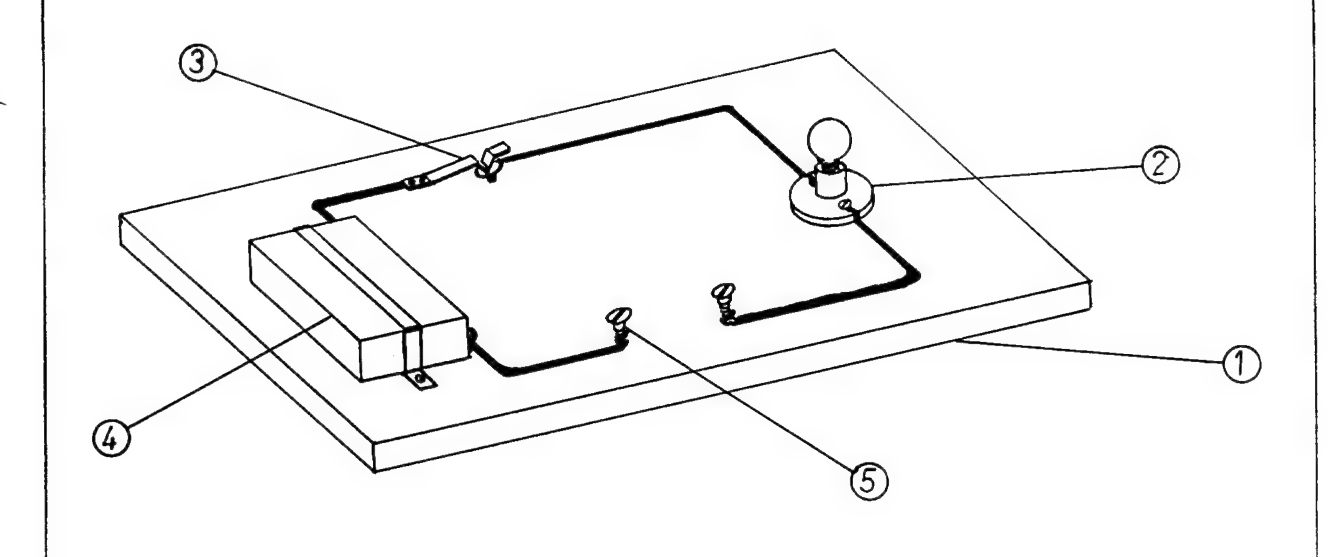
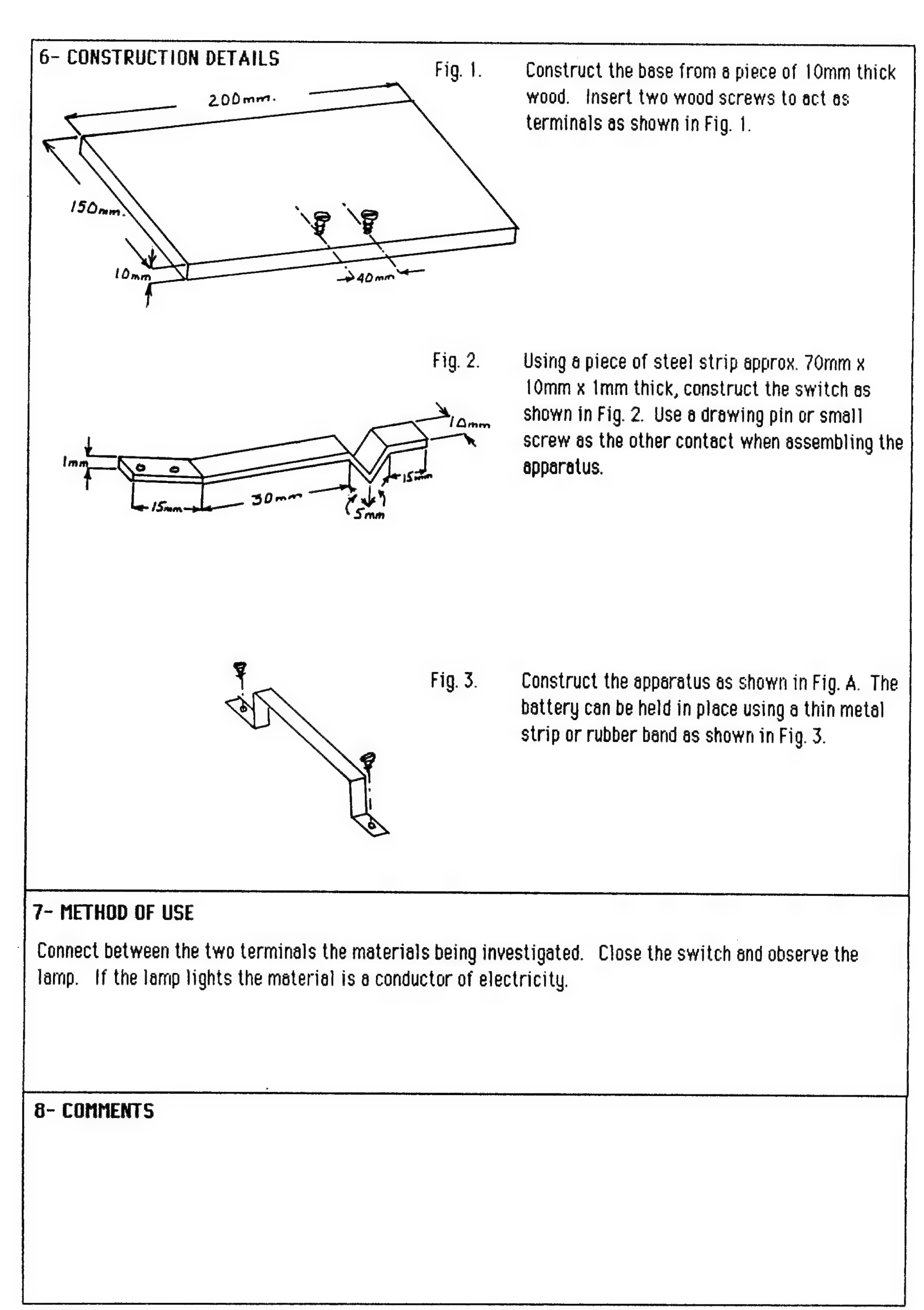


FIG . A.

5- MATERIALS FOR CONSTRUCTION

Components	Qty	Materials Required	Dimensions
1. Base.	1.	Wood.	200mm x 150mm x 10mm.
2. Indicator.	1.	6 volt bulb and bulb holder.	
3. Switch.	1.	Sheet metal strip.	10mm wide x 1 mm thick.
4. Power Supply.	1.	6 volt battery.	
5. Terminals.	2.	Screws.	approx. 25mm long.
		Insulated copper wire.	approx. 1 metre.
		Assorted screws.	

Tools: screwdriver; wire cutters; tin snips.



6- CONSTRUCTION DETAILS

Fig. 1. Construct the base from a piece of 10mm thick wood. Insert two wood screws to act as terminals as shown in Fig. 1.

Fig. 2. Using a piece of steel strip approx. 70mm x 10mm x 1mm thick, construct the switch as shown in Fig. 2. Use a drawing pin or small screw as the other contact when assembling the apparatus.

Fig. 3. Construct the apparatus as shown in Fig. A. The battery can be held in place using a thin metal strip or rubber band as shown in Fig. 3.

7- METHOD OF USE

Connect between the two terminals the materials being investigated. Close the switch and observe the lamp. If the lamp lights the material is a conductor of electricity.

8- COMMENTS

1- ITEM

AN ELECTROSCOPE.

2- PURPOSE

To demonstrate the existence of electrical charges and to test for positive and negative charges.

3- INFORMATION SUBMITTED BY

Pedagogical Academy, Nicosia, Cyprus.

4- LINE DRAWING OF PROTOTYPE

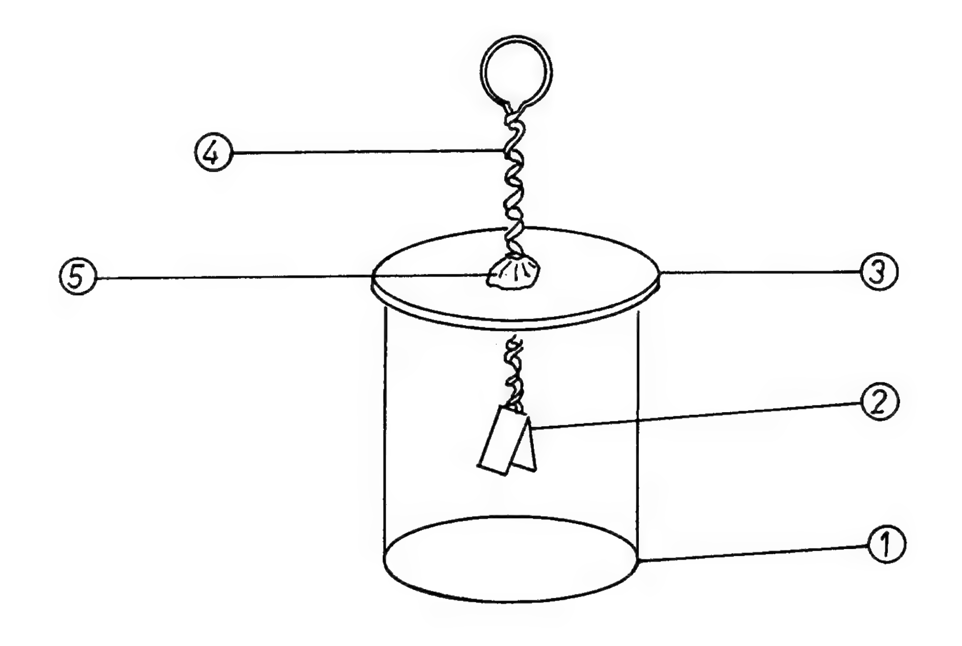


FIG. A.

5- MATERIALS FOR CONSTRUCTION

Components	Qty	Materials Required	Dimensions
1. Container.	1.	Glass Jar (wide mouthed).	
2. Leaves.	2.	Aluminium Foil.	50mm x 10mm x 0.1mm.
3. Lid.	1.	Wood (or plastic)	To suit jar dia.
4. Conductor.	1.	Copper Wire (stiff).	
5. Conductor Support.	1.	Plasticine.	

Tools: Scissors; pliers; woodsaw; drill and drill bit.

6- CONSTRUCTION DETAILS

Fig. 1. From a thin sheet of wood construct a lid for the jar as shown in Fig. 1. Drill a hole through the centre as indicated.

Fig. 2. From a piece of thin aluminium foil cut out two leaves of approx. 50mm x 10mm (the actual size will depend upon the size of jar available). Using the stiff copper wire construct the conductor by twisting the wire as indicated in Fig. 2. Pass the conductor through the hole in the lid. Clip the two pieces of foil in place by squeezing the two open ends of the twisted wire.

Assemble the apparatus as shown in Fig. A. Use plasticine to fix the conductor in place.

7- METHOD OF USE

When the loop is touched by a polythene rod, which has been charged by rubbing it with a soft cloth, the negative charge passes to the foils. Since like charges repel the leaves diverge. If an unknown charge X is brought near to the loop an increased divergence will indicate that the charge of X is negative. A positive charge would cause the leaves to collapse.

8- COMMENTS

1- ITEM

MAGNETIC INTERACTION APPARATUS.

2- PURPOSE

To demonstrate the interaction between two magnetic poles.

3- INFORMATION SUBMITTED BY

Beijing Teaching Aids Centre, Hengshui Prefecture, Hebei Province, China.

4- LINE DRAWING OF PROTOTYPE

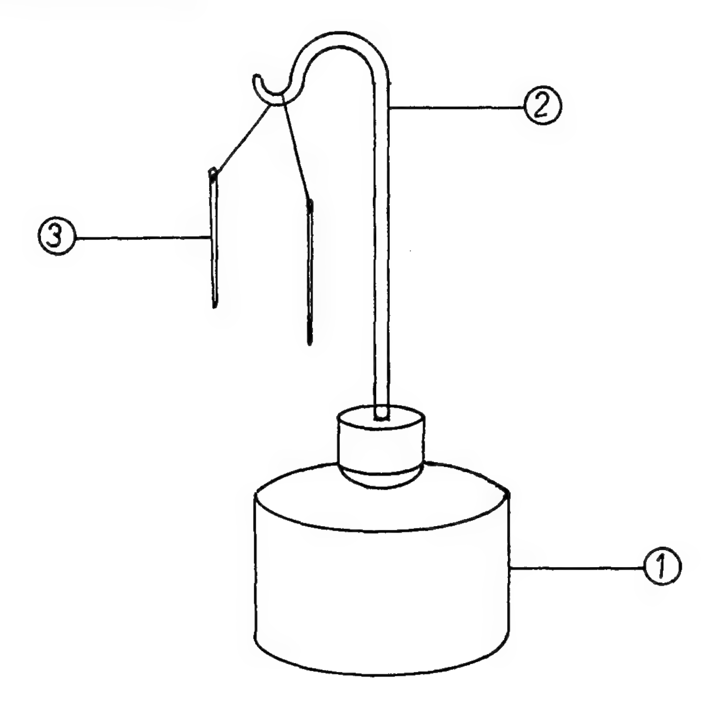


FIG. A.

5- MATERIALS FOR CONSTRUCTION

Components	Qty	Materials Required	Dimensions
1. Stand.	1.	Ink Bottle.	as available.
2. Support Rod.	1.	Copper (or Brass) Wire.	approx. 2mm dia.
3. Magnets.	2.	Steel Sewing Needles.	
		Sand.	
		Cotton or Thread.	
		Magnet.	

Tools: Hammer, nail, scissors.

6- CONSTRUCTION DETAILS

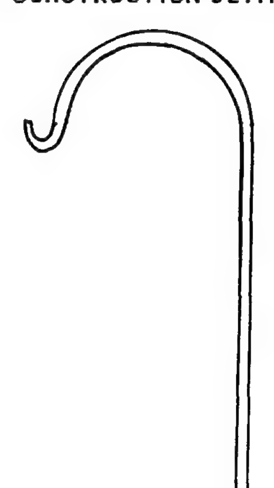


Fig. 1.

Obtain an empty ink bottle and fill it with sand. Make a hole in the centre of the lid of the bottle of approximately 2mm dia.

Using a piece of 2mm. dia. copper or brass wire bend it to the shape indicated in Figure 1. Insert this stand through the hole in the bottle lid.

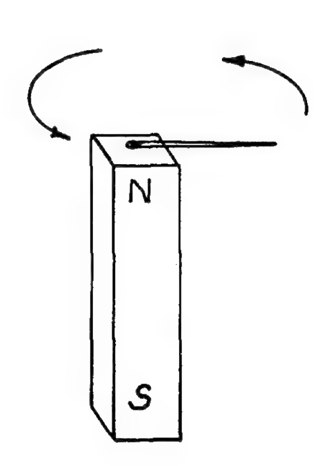


Fig. 2.

Magnetise two steel sewing needles by stroking them slowly across one pole of a magnet. Move the needle in one direction only as indicated in Fig. 2.

About 30 strokes may be sufficient to magnetise the needle.

Tie each needle to the ends of a length of thread and suspend them over the hook of the stand.

7- METHOD OF USE

Having magnetised both needles in the same manner they will have the same polarity as each other. When suspended from the hook they will try to repel one another showing that like poles repel.

8- COMMENTS

There will be a tendency for the pointed end of one needle to be attracted to the eye end of the other one, when they are freely suspended. This tendency can be reduced by winding the thread twice around the hook

1- ITEM

A FISHING GAME.

2- PURPOSE

To demonstrate the properties of magnets.

3- INFORMATION SUBMITTED BY

Pedagogical Academy, Nicosia, Cyprus.

4- LINE DRAWING OF PROTOTYPE

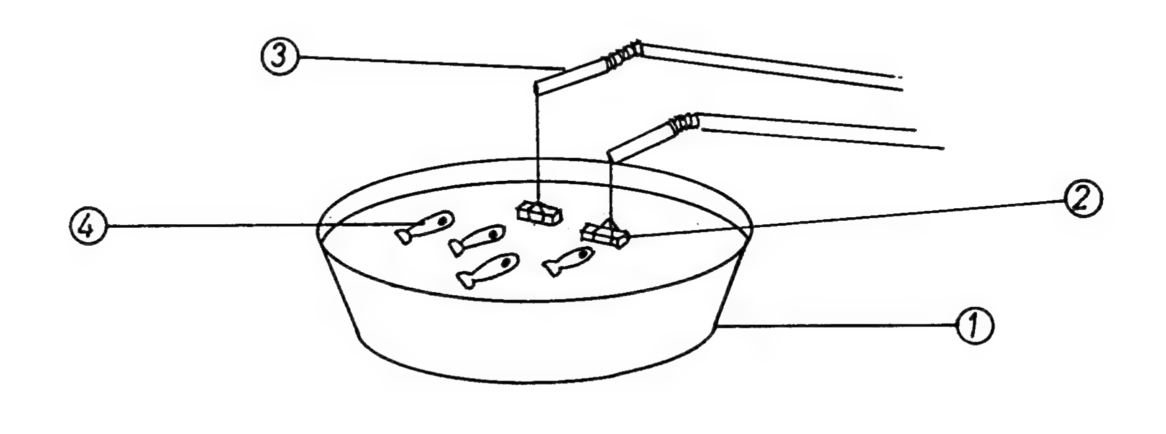


FIG. A.

5- MATERIALS FOR CONSTRUCTION

Components	Qty	Materials Required	Dimensions
1. Container.	1.	Bowl.	
2. Magnets.	2.	Small Magnets.	as available.
3. Rods(Fishing)	2.	Drinking Straws.	
4. Fishes.	4.	Expanding Polystyrene.	as available.
	4.	Steel drawing pins.	
		Thread.	

Tools: Knife; Scissors.

6- CONSTRUCTION DETAILS

From a thin sheet of expanded polystyrene (or stiff cardboard) cut out a number of "fishes". Insert a small steel drawing pin into each fish as an "eye".

Suspend small magnets from the straws using thread.

7- METHOD OF USE

Fill a blue-coloured bowl with water and float the fishes on the water. Using the straws with the magnets suspended as fishing rods catch some fish.

8- COMMENTS

As a variation to this game some of the fishes can have brass drawing pins instead of steel ones. Two (or more) children attempt to catch as many fish as they can within a given period. "Why are there some left swimming?" leads to the idea of magnetic and non-magnetic materials.

1- ITEM

DANCING DOLLS.

2- PURPOSE

To demonstrate the properties of magnets

3- INFORMATION SUBMITTED BY

Pedagogical Academy, Nicosia, Cyprus.

4- LINE DRAWING OF PROTOTYPE

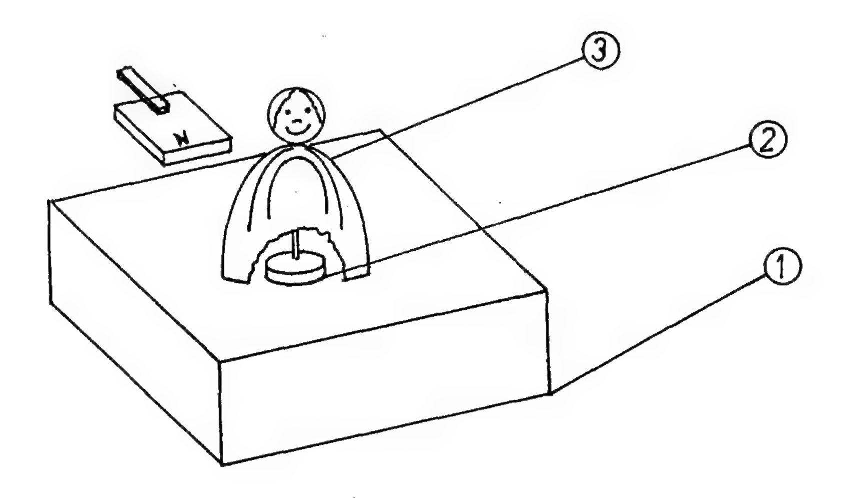


FIG. A.

5- MATERIALS FOR CONSTRUCTION

Components	Qty	Materials Required	Dimensions
1. Stage.	1.	Cardboard Box.	as available.
2. Support for Dancer.	1.	Cork and toothpick.	as available.
3. Dancer.	1.	Eggshell (egg box) and small pith ball.	
4. Magnet.	1.	Magnet (small).	as available.
	1.	Steel drawing pin.	
		Adhesive.	

Tools: Small knife; paint and small paint brush.

6- CONSTRUCTION DETAILS

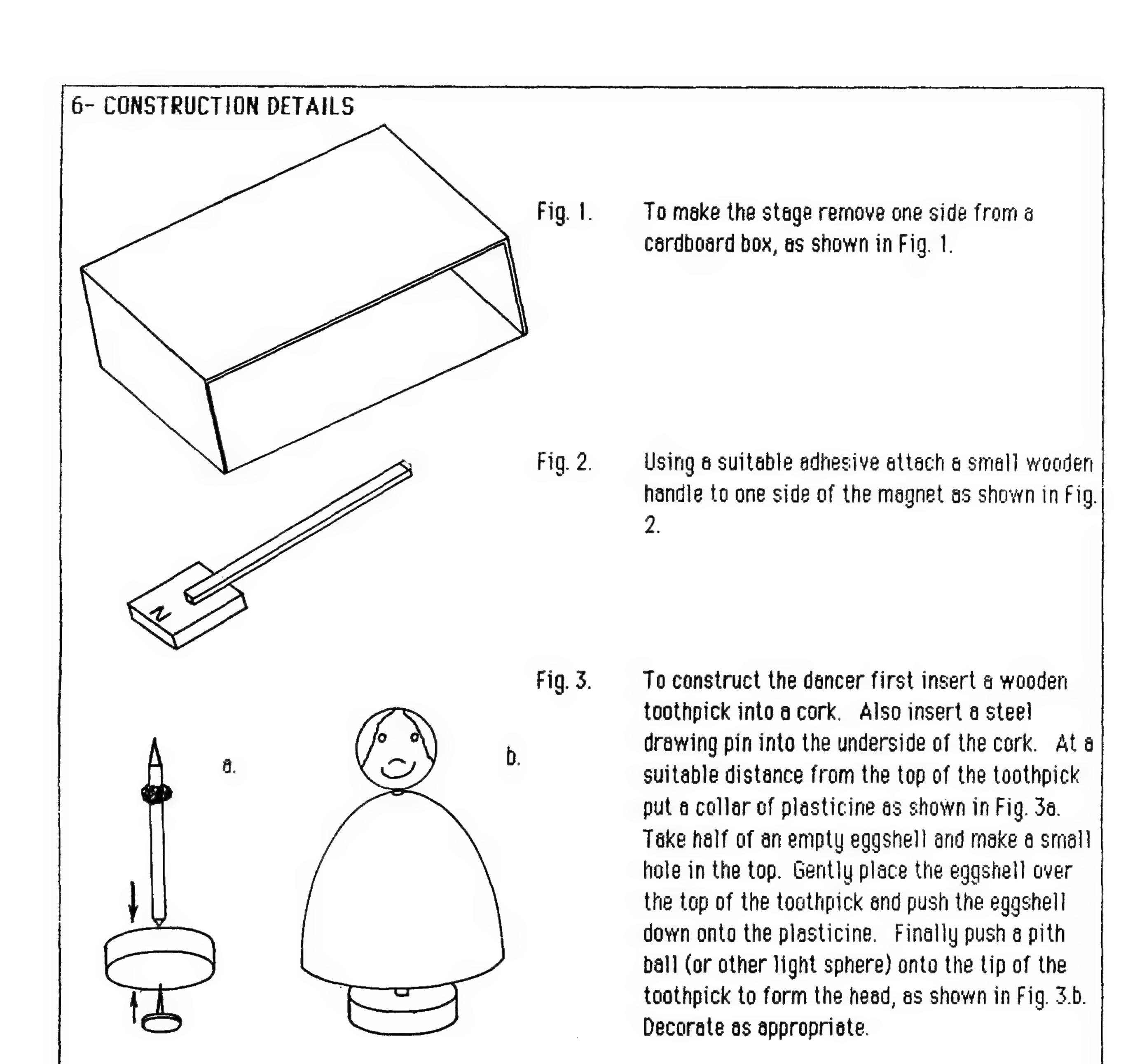


Fig. 1. To make the stage remove one side from a cardboard box, as shown in Fig. 1.

Fig. 2. Using a suitable adhesive attach a small wooden handle to one side of the magnet as shown in Fig. 2.

Fig. 3. To construct the dancer first insert a wooden toothpick into a cork. Also insert a steel drawing pin into the underside of the cork. At a suitable distance from the top of the toothpick put a collar of plasticine as shown in Fig. 3a. Take half of an empty eggshell and make a small hole in the top. Gently place the eggshell over the top of the toothpick and push the eggshell down onto the plasticine. Finally push a pith ball (or other light sphere) onto the tip of the toothpick to form the head, as shown in Fig. 3.b. Decorate as appropriate.

7- METHOD OF USE

By moving the magnet under the stage the dancer will also move due to magnetic attraction between the magnet and the steel pin. Usually more than one dancer is used.

8- COMMENTS

An alternative to an eggshell is the egg holder in a plastic egg carton or a small tennis ball.

1- ITEM

A COMPASS. (i)

2- PURPOSE

To construct a simple compass.

3- INFORMATION SUBMITTED BY

Pedagogical Academy, Nicosia, Cyprus.

4- LINE DRAWING OF PROTOTYPE

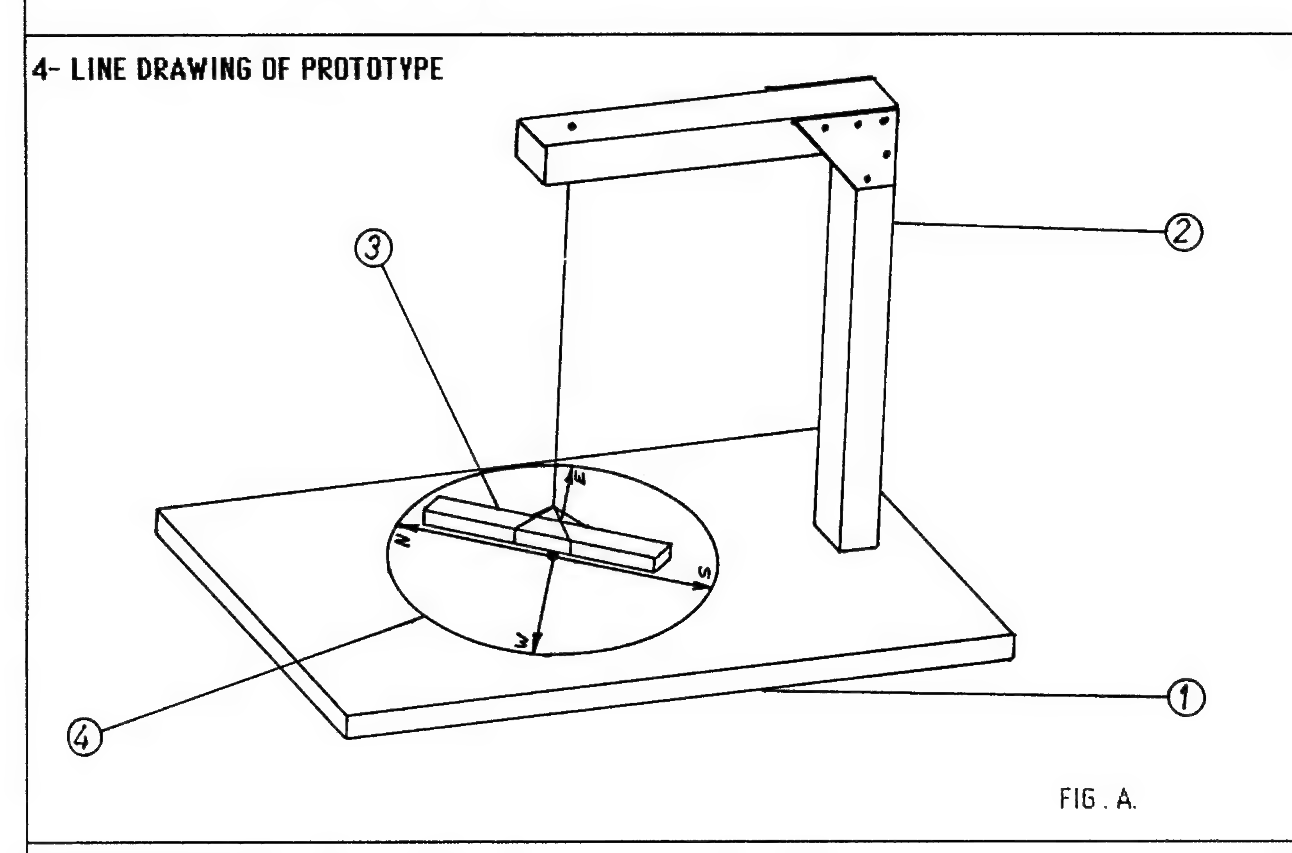


FIG . A.

5- MATERIALS FOR CONSTRUCTION

Components	Qty	Materials Required	Dimensions
1. Base.	1.	Wood.	200mm x 150mm x 6mm.
2. Support.	1.	Wood.	400mm x 20mm x 20mm.
3. Magnet.	1.	Magnet.	as available.
4. Disc.	1.	Wood.	100mm dia. x 3mm.
		White Paper.	
		Thread.	
		Adhesive.	

Tools: Woodsaw; hammer; nails; scissors; drill and drill bits; small chisel.

6- CONSTRUCTION DETAILS

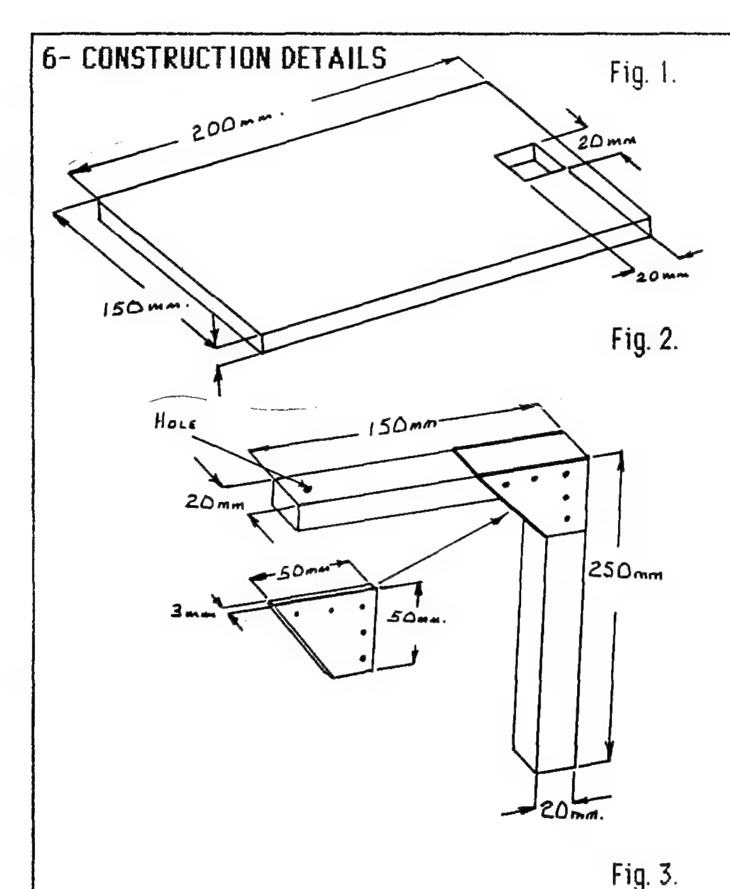


Fig. 1. From a sheet of approx. 6mm wood construct the base as shown in Fig. 1. Using a drill and chisel cut out the hole for the support.

Fig. 2. Cut two lengths from the 20mm x 20mm square wood according to the sizes shown in Fig. 2. From a piece of 3mm thick plywood cut two gusset plates 50mm x 50mm as shown. Using these two plates fix the cross member to the upright by gluing and nailing them in place.

Glue and nail the upright into the hole in the base.

Suspend the magnet from the cross member through the small hole drilled at the end.

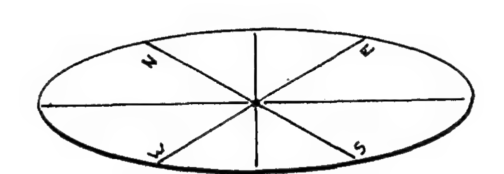


Fig. 3. From a piece of 3mm thick plywood cut out a disc of 100mm diameter. From a sheet of white paper mark out the points of the compass as shown in Fig. 3. Glue the paper disc to the wooden disc. and drill a small hole at the centre. Place a BRASS washer under the disc, and using a BRASS nail or pin, locate the disc centrally under the suspended magnet.

7- METHOD OF USE

Allow the magnet to come to rest which will be in a North-South direction. Rotate the disc until the North-South line is in line with the North-South line of the magnet. Other directions can then be located.

8- COMMENTS

1- ITEM

A COMPASS. (ii)

2- PURPOSE

To construct a simple compass and demonstrate that the earth has a magnetic field.

3- INFORMATION SUBMITTED BY

Beijing Teaching Aids Centre, Hengshui Prefecture, Hebei Province, China.

4- LINE DRAWING OF PROTOTYPE

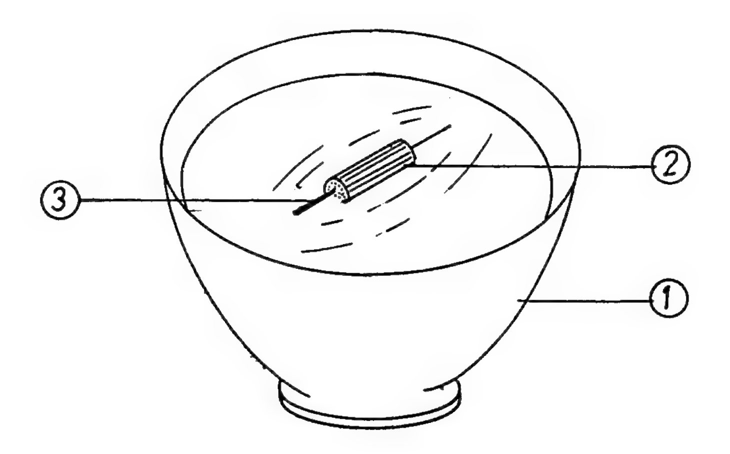


FIG. A.

5- MATERIALS FOR CONSTRUCTION

Components	Qty	Materials Required	Dimensions
1. Bowl	1.	Glass or China Bowl.	as available.
2. Float.	1.	Sorghum stalk (or piece of bamboo, or cork).	to suit needle.
3. Compass needle.	1.	Steel Darning needle. (or large sewing needle).	as available.
		Magnet	

6- CONSTRUCTION DETAILS

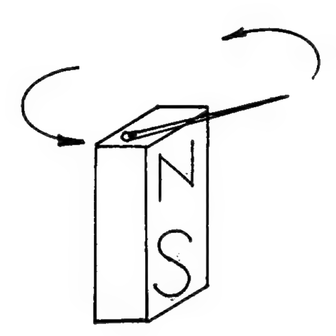


Fig. 1.

To magnetise the needle stroke one end (the eye end) approximately 30 times across the North pole end of a permanent magnet. Move the needle in one direction only as shown in Fig. 1. Test that the needle is magnetised against a steel nail or similar object.

Using a sharp knife obtain a clean cut section of sorghum stalk.

Insert the magnetised needle through the stalk.

7- METHOD OF USE

Fill a bowl with water and lower the needle unit onto the water; the complete arrangement is a compass. Wait for approximately half a minute before taking a reading (the eye end of the needle will indicate the South direction).

8- COMMENTS

Since the cuticle of sorghum stalk is quite brittle and the duramen is very soft, it is not easy to get a clean cut section. Cut several sections and use the best one...

1- ITEM

A CLEPSYDRA. (Water Clock).

2- PURPOSE

To construct a water clock for measuring time.

3- INFORMATION SUBMITTED BY

Pedagogical Academy, Nicosia, Cyprus.



4- LINE DRAWING OF PROTOTYPE

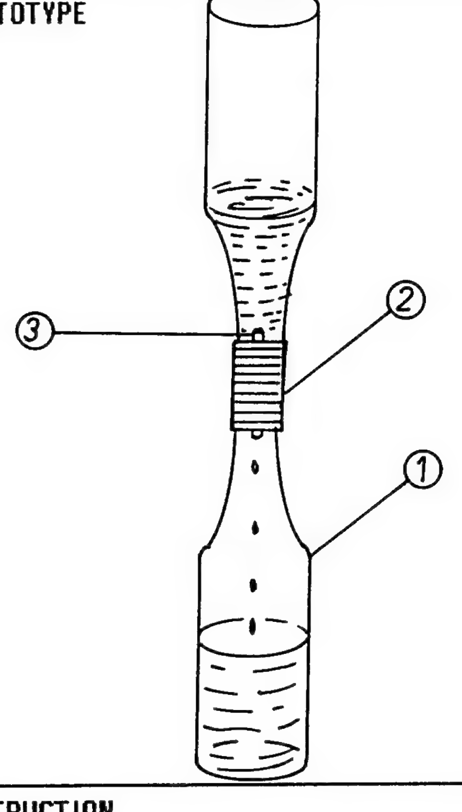


FIG. A.

5- MATERIALS FOR CONSTRUCTION

Components	Qty	Materials Required	Dimensions
1. Bottles.	2.	Glass bottles.	as available.
2. Stoppers.	2.	Rubber Bungs with one hole.	
3. Glass Tube.	1.	Glass Tubing	3mm i.d. x 60mm.
		Waterproof Tape (Sellotape)	

6- CONSTRUCTION DETAILS

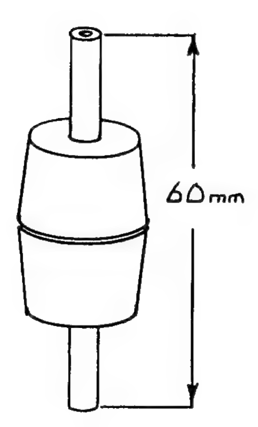


Fig. 1.

Fig. 1. indicates the arrangement of the two stoppers on the piece of glass tubing.

7- METHOD OF USE

Pour a quantity of water into one bottle. Insert the stopper arrangement and then attach the empty bottle. If necessary seal the stoppers using the waterproof tape. Turn the bottles upside down. When the water has dripped into the empty lower bottle the procedure can be repeated.

The time given to empty one bottle can be measured using a clock. Similarly it would be possible to 'calibrate' the apparatus in time intervals e.g. the time taken to quarter empty the bottle, half empty the bottle and so on. The apparatus could be then used as a timing device.

8- COMMENTS

1- ITEM

A TIMING DEVICE.

2- PURPOSE

To measure intervals of time.

3- INFORMATION SUBMITTED BY

Pedagogical Academy, Nicosia, Cyprus.

4- LINE DRAWING OF PROTOTYPE

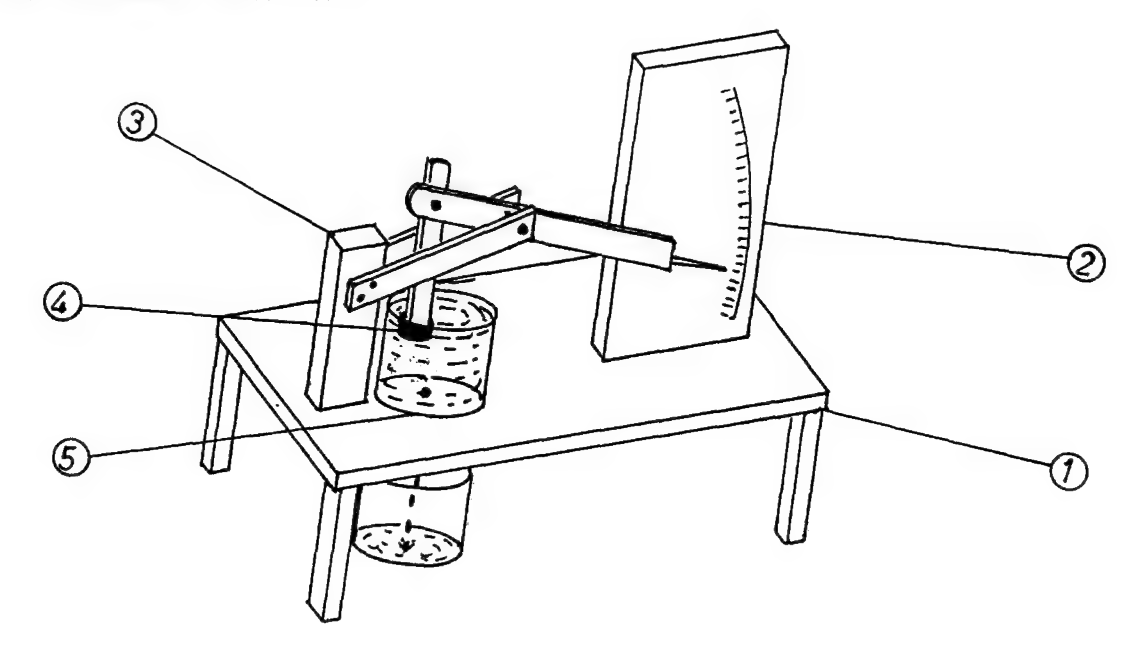


Fig. A.

5- MATERIALS FOR CONSTRUCTION

Components	Qty	Materials Required	Dimensions
1. Stand.	1.	Wood.	650mm x 300mm x 10mm.
	4.	Wood.	30mm x 30mm x 200mm.
2. Scale Board.	1.	Wood.	300mm x 100mm x 3mm.
3. Lever and float mechanism.	1.	Wood.	1200mm x 15mm x 5mm.
			150mm x 50mm x 20mm.
4. Float.	1.	Cork.	
5. Container.	2.	Plastic (or glass).	approx. 150mm dia x 100mm.
		Nails.	
		Adhesive.	
		Nuts and bolts.	
		Tools: Woodsaw; hammer; scissors	

6- CONSTRUCTION DETAILS

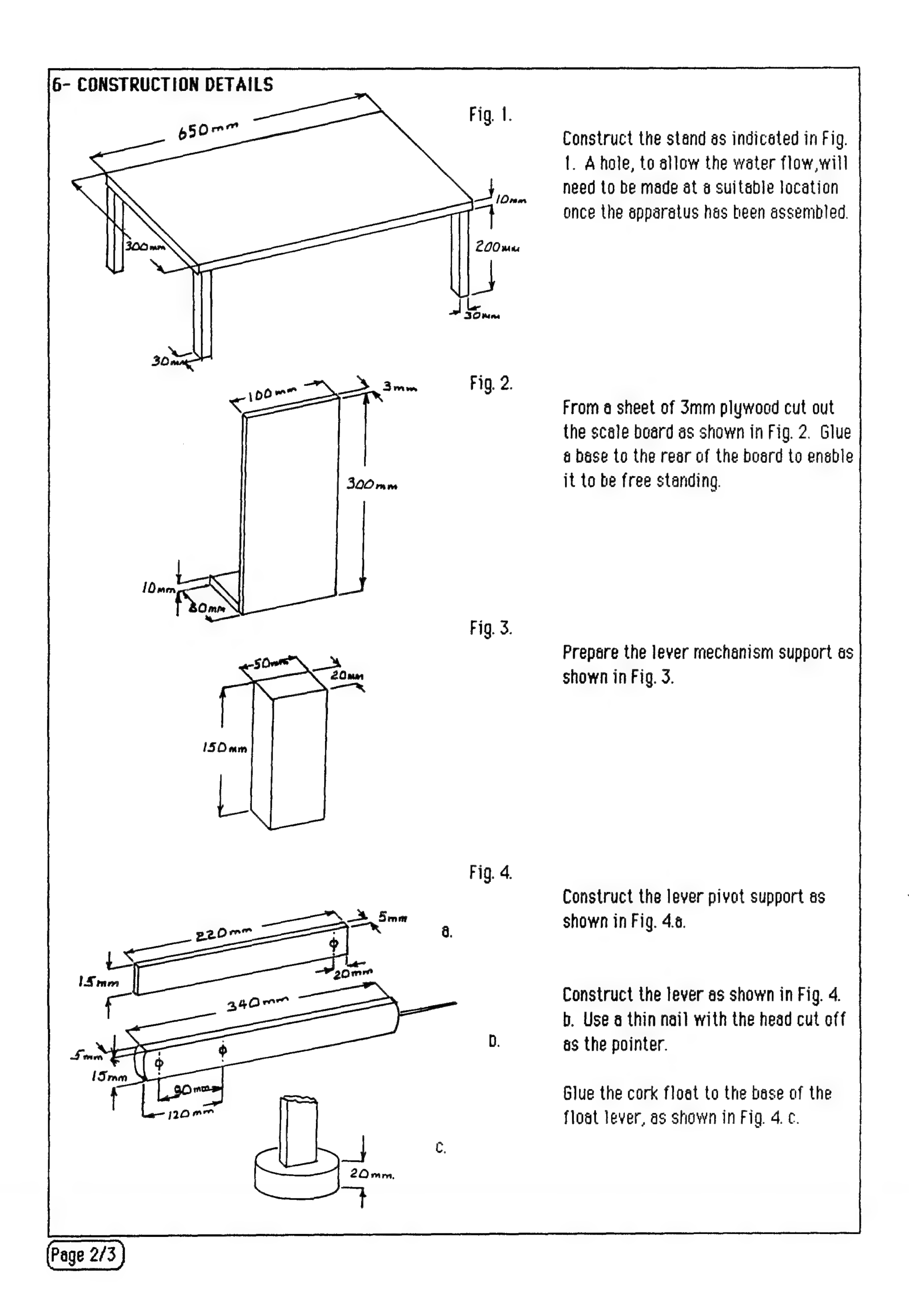


Fig. 1.

Construct the stand as indicated in Fig. 1. A hole, to allow the water flow, will need to be made at a suitable location once the apparatus has been assembled.

Fig. 2.

From a sheet of 3mm plywood cut out the scale board as shown in Fig. 2. Glue a base to the rear of the board to enable it to be free standing.

Fig. 3.

Prepare the lever mechanism support as shown in Fig. 3.

Fig. 4.

Construct the lever pivot support as shown in Fig. 4.a.

Construct the lever as shown in Fig. 4. b. Use a thin nail with the head cut off as the pointer.

Glue the cork float to the base of the float lever, as shown in Fig. 4. c.

6- CONSTRUCTION DETAILS (Continued)

Fig. 5.

Assemble the lever mechanism as shown in Fig. 5. above. The distances between the pivots should be adjusted such that the float lever is slightly heavier than the pointer lever, but at the same time the float should rest on the surface of the water.

Assemble the apparatus as shown in Fig. A. When the containers have been satisfactorily located drill a hole in the base of the upper container (approx. 2mm dia.) and a 10mm dia hole in the stand below it.

7- METHOD OF USE

Clip a piece of white paper onto the scale board. Fill the one container with water whilst blocking the hole in the bottom. As the water rises the float rises with it and the pointer moves downwards over the scale board. When the container is full the pointer will register zero which should be marked on the scale board. Unblock the hole. As the water slowly runs into the lower container the pointer will move upwards. Calibration can take place by marking off the position of the pointer in terms of intervals of time.

8- COMMENTS

1- ITEM

A PENDULUM.

2- PURPOSE

To examine the variation of length against the period or frequency of a pendulum.

3- INFORMATION SUBMITTED BY

Pedagogical Academy, Nicosia, Cyprus.

4- LINE DRAWING OF PROTOTYPE

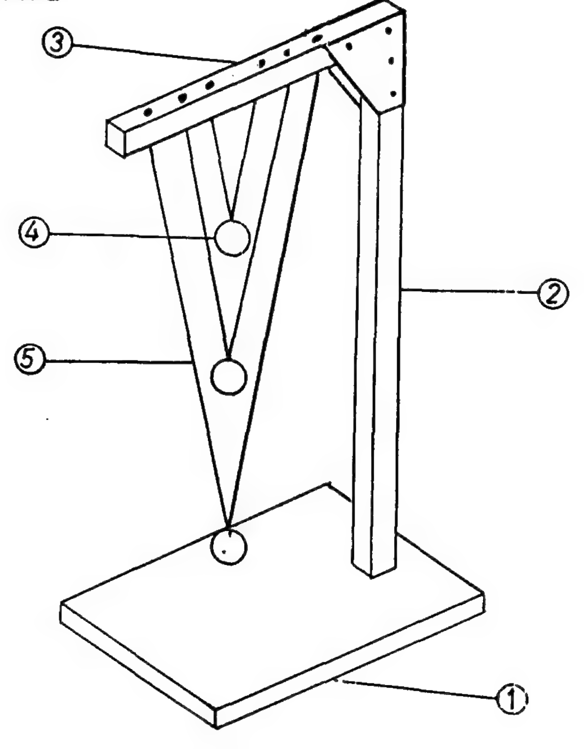
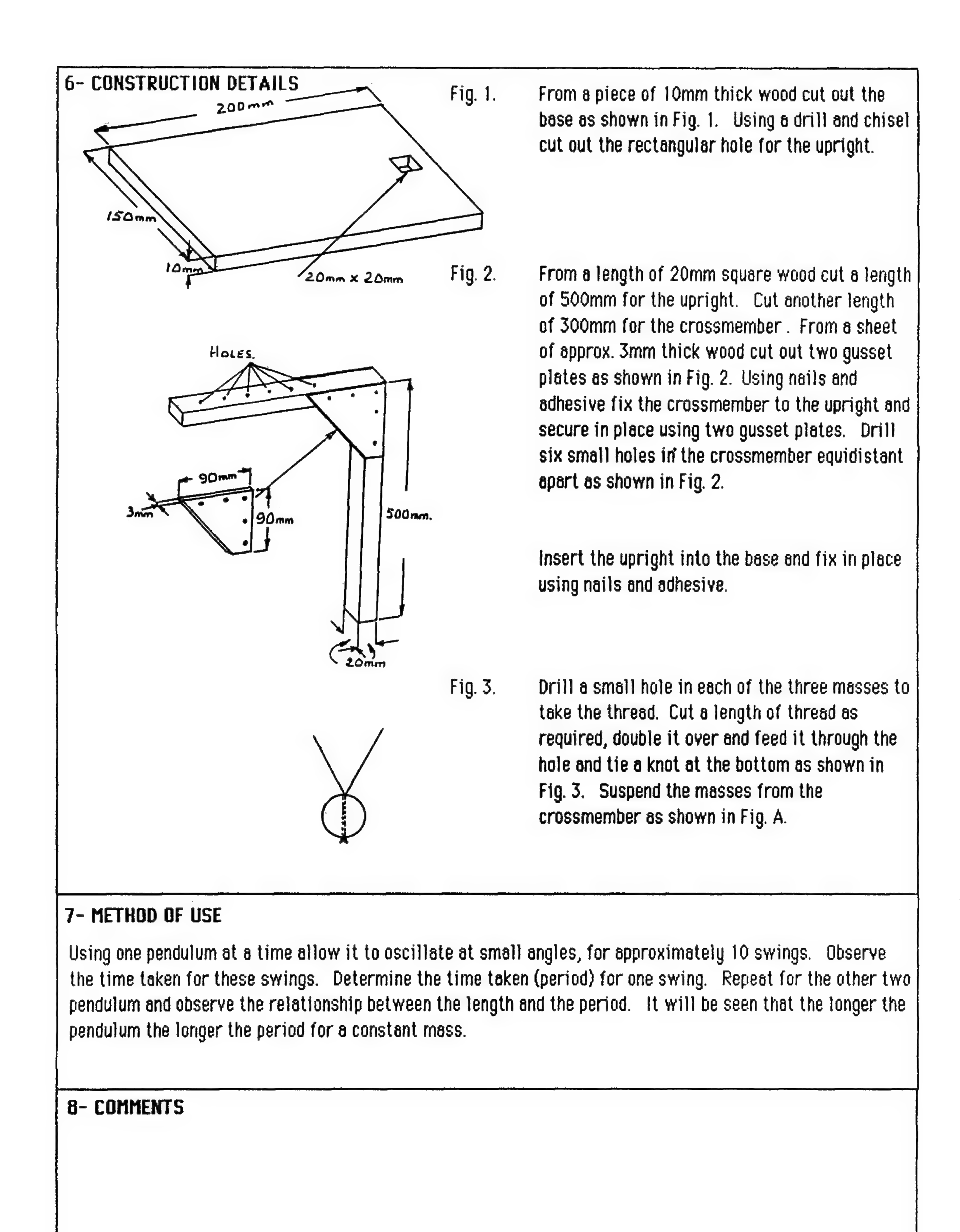


FIG. A.

5- MATERIALS FOR CONSTRUCTION

Components	Qty	Materials Required	Dimensions
1. Base.	1.	Wood.	200mm x 150mm x10mm.
2. Upright.	1.	Wood.	500mm x 20mm x 20mm.
3. Crossmember.	1.	Wood.	300mm x 20mm x 20mm
4. Mass.	3.	Solid Rubber (or metal).	approx. 20mm dia.
5. Thread.		Thread.	approx. 2 metre.

Tools: Woodsaw; hammer; nails; adhesive; drill and drill bits; scissors.



6- CONSTRUCTION DETAILS

Fig. 1. From a piece of 10mm thick wood cut out the base as shown in Fig. 1. Using a drill and chisel cut out the rectangular hole for the upright.

Fig. 2. From a length of 20mm square wood cut a length of 500mm for the upright. Cut another length of 300mm for the crossmember. From a sheet of approx. 3mm thick wood cut out two gusset plates as shown in Fig. 2. Using nails and adhesive fix the crossmember to the upright and secure in place using two gusset plates. Drill six small holes in the crossmember equidistant apart as shown in Fig. 2.

Insert the upright into the base and fix in place using nails and adhesive.

Fig. 3. Drill a small hole in each of the three masses to take the thread. Cut a length of thread as required, double it over and feed it through the hole and tie a knot at the bottom as shown in Fig. 3. Suspend the masses from the crossmember as shown in Fig. A.

7- METHOD OF USE

Using one pendulum at a time allow it to oscillate at small angles, for approximately 10 swings. Observe the time taken for these swings. Determine the time taken (period) for one swing. Repeat for the other two pendulum and observe the relationship between the length and the period. It will be seen that the longer the pendulum the longer the period for a constant mass.

8- COMMENTS

1- ITEM

A WINDMILL.

2- PURPOSE

To show the conversion of wind energy into mechanical (Kinetic) energy.

3- INFORMATION SUBMITTED BY

Pedagogical Academy, Nicosia, Cyprus.

4- LINE DRAWING OF PROTOTYPE

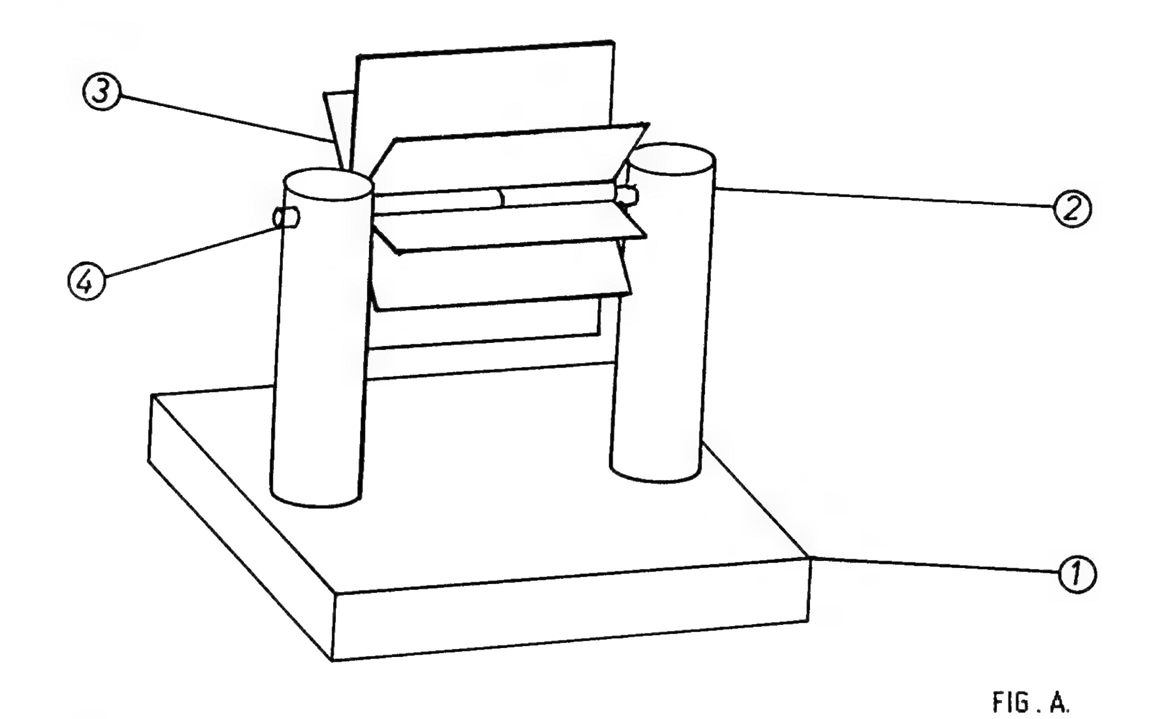


FIG. A.

5- MATERIALS FOR CONSTRUCTION

Components	Qty	Materials Required	Dimensions
1. Base.	1.	Cardboard Box.	as available.
2. Supports.	2.	Cardboard Tubes.	approx. 250mm Long.
3. Wind Vanes.	1.	Cardboard.	as available..
4. Axis.	1.	Pencil (or other round rod).	
		Sellotape.	
		Adhesive.	

Tools: Scissors; knife.

6- CONSTRUCTION DETAILS

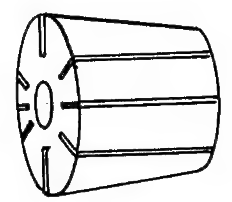


Fig. 1.

To construct the rotor obtain two large corks and bore a hole in each one to take a pencil. Cut slots (8) longitudinally in the cork as shown in Fig. 1. Push the two corks onto a pencil with the slot in line.

Measure the length between the two outer faces of the corks. Using this dimension cut out eight vanes from a sheet of stiff cardboard (or thin aluminium sheet). Insert these vanes into the slots using a suitable adhesive to fix them in place.

Obtain a large cardboard box and two cardboard tubes of approx. 250mm long and 40mm dia. Using the dimension of the length of the vanes cut holes in the box and insert the two tubes. Before gluing the tubes in place insert the rotor, after making holes for the axis at a suitable height in each tube. Use sellotape or glue to fix the tubes in place.

7- METHOD OF USE

Place the apparatus out in the air and observe the rotation.

8- COMMENTS

1- ITEM

A CENTRIFUGAL MACHINE.

2- PURPOSE

To observe the circular motion of a mass on a pivoted arm at varying speeds (Centripetal Force).

3- INFORMATION SUBMITTED BY

Pedagogical Academy, Nicosia, Cyprus.

4- LINE DRAWING OF PROTOTYPE

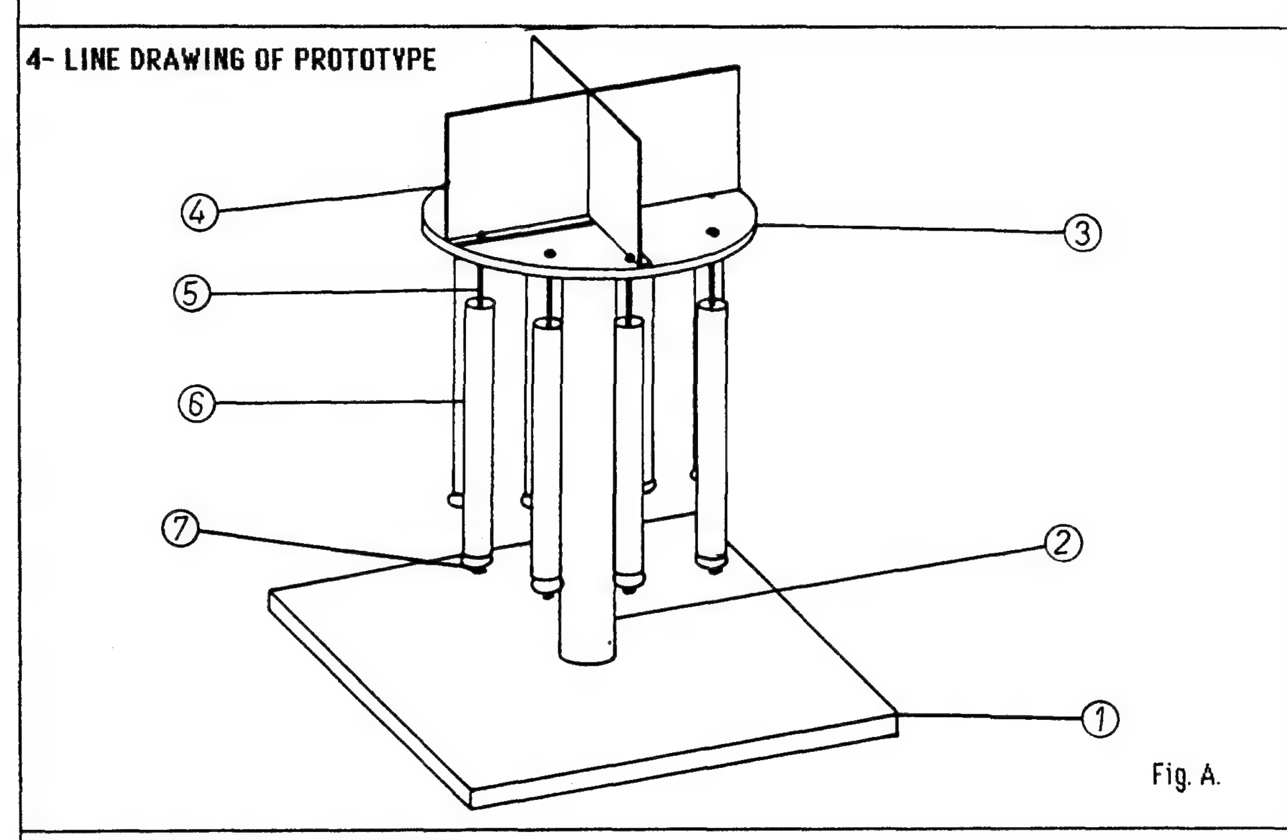


Fig. A.

5- MATERIALS FOR CONSTRUCTION

Components	Qty	Materials Required	Dimensions
1. Base.	1.	Wood.	200mm x 150mm x 10mm.
2. Support.	1.	Wood.	20mm dia. x 300mm long.
3. Disc.	1.	Wood.	80mm dia x 3mm.
4. Vanes.	1.	Cardboard.	160mm x 50mm x 1mm.
5. Suspension.	8.	Thread.	2 metres.
6. Tube.	8.	Straws.	
7. Mass.	8.	Heavy Buttons.	as available.
	2.	Metal Washers.	
		Nails.	
		Adhesive.	

Tools: Woodsaw; drill and drill bits; scissors.

6- CONSTRUCTION DETAILS

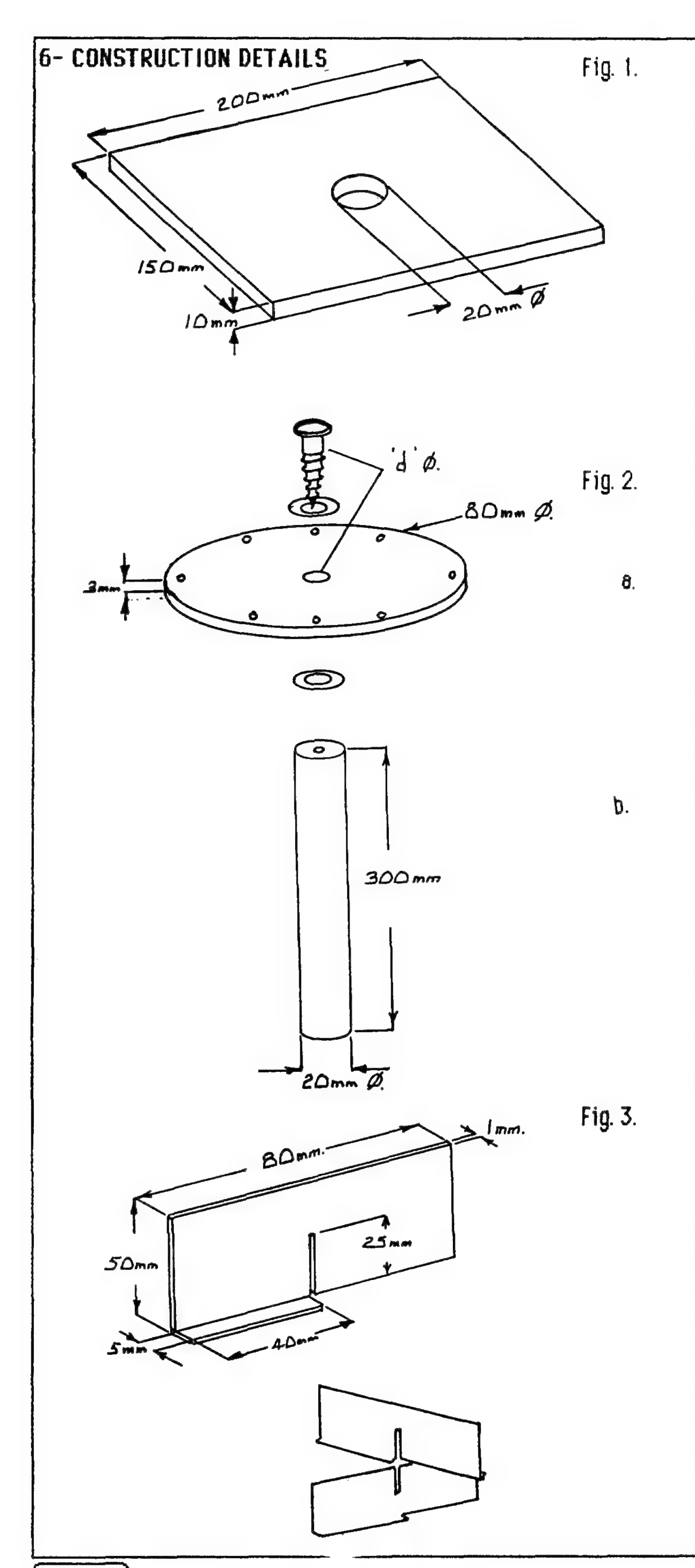


Fig. 1. From a sheet of 10mm thick plywood construct the base as shown in Fig. 1. The 20mm dia. hole should be a tight fit for a piece of 20mm dia. dowelling.

Fig. 2. a. From a sheet of 3mm thick plywood cut out a disc of approx. 80mm diameter. Drill a hole in the centre, the diameter of which should be slightly larger than the diameter of an available wood screw. On a circle of 70mm dia. drill 8 symmetrically placed small holes through which thread can be passed, as indicated in Fig. 2a.

b. From a piece of 20mm dia wood dowelling construct the support as shown in Fig. 2b. Drill a small hole in one end to provide an initial start for the screw.

Glue the support into the hole in the base. Attach the disc to the support, so that it is free to rotate, using the two washers and a screw, as shown in Fig. 2.

Fig. 3. From a piece of stiff cardboard cut out two vanes as shown in Fig. 3. The 5mm extra piece shown for gluing to the disc should be as shown on one vane, and on the upper edge on the second vane. Assemble the two and glue them to the top of the disc, cutting where necessary to allow for the head of the screw.

6- CONSTRUCTION DETAILS (Continued)

Fig. 4.

Prepare 8 masses by suspending heavy buttons (all the same) on lengths of thread of approx. 250mm long. Slide a long straw over each piece of thread. Finally feed each piece of thread through one of the holes in the disc as shown in Fig. A.

7- METHOD OF USE

Blow air against the vanes and observe the position of each button. The faster the spin the higher the buttons, and the greater their circumference of rotation.

8- COMMENTS

1- ITEM

A PADDLE BOAT.

2- PURPOSE

To demonstrate the change of energy from one form (Dynamic) into another (Kinetic).

3- INFORMATION SUBMITTED BY

Pedagogical Academy, Nicosia, Cyprus.

4- LINE DRAWING OF PROTOTYPE

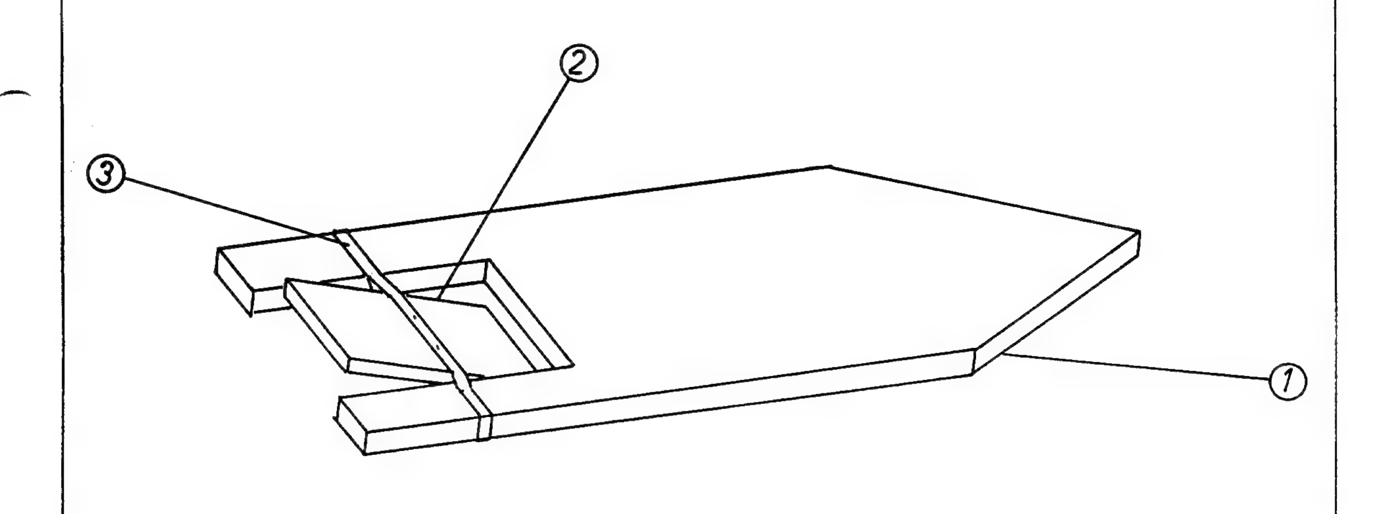


FIG. A.

5- MATERIALS FOR CONSTRUCTION

Components	Qty	Materials Required	Dimensions
1. Boat.	1.	Wood.	200mm x 100mm x 5mm.
2. Paddle.	1.	Wood.	55mm x 30mm x 5mm.
3. Power Supply.	1.	Rubber Band.	

Tools: Woodsaw; chisel.

6- CONSTRUCTION DETAILS

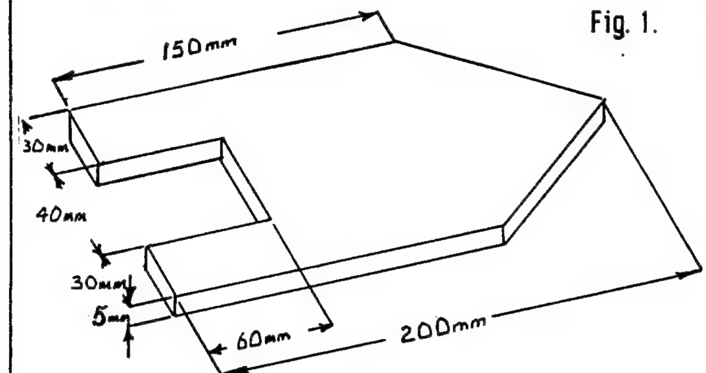


Fig. 1. From a sheet of 5mm plywood cut out the boat as indicated in Fig. 1.

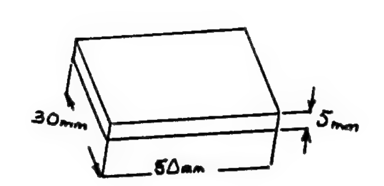


Fig. 2. From the piece of wood cut out from the rear of the boat make the paddle.

Using a rubber band as the power source assemble the boat asshown in Fig. A.
To secure the paddle, pin or staple the rubber band to the paddle.

7- METHOD OF USE

Wind up the paddle by rotating it. Place the boat onto the surface of a tank filled with water. Release the paddle and observe the movement of the boat.

8- COMMENTS

1- ITEM

A STEAM-JET FLOAT.

2- PURPOSE

To demonstrate Newton's Third Law of Motion (action/reaction) and to demonstrate the exchange of Heat to Kinetic Energy.

3- INFORMATION SUBMITTED BY

Pedagogical Academy, Nicosia, Cyprus.

4- LINE DRAWING OF PROTOTYPE

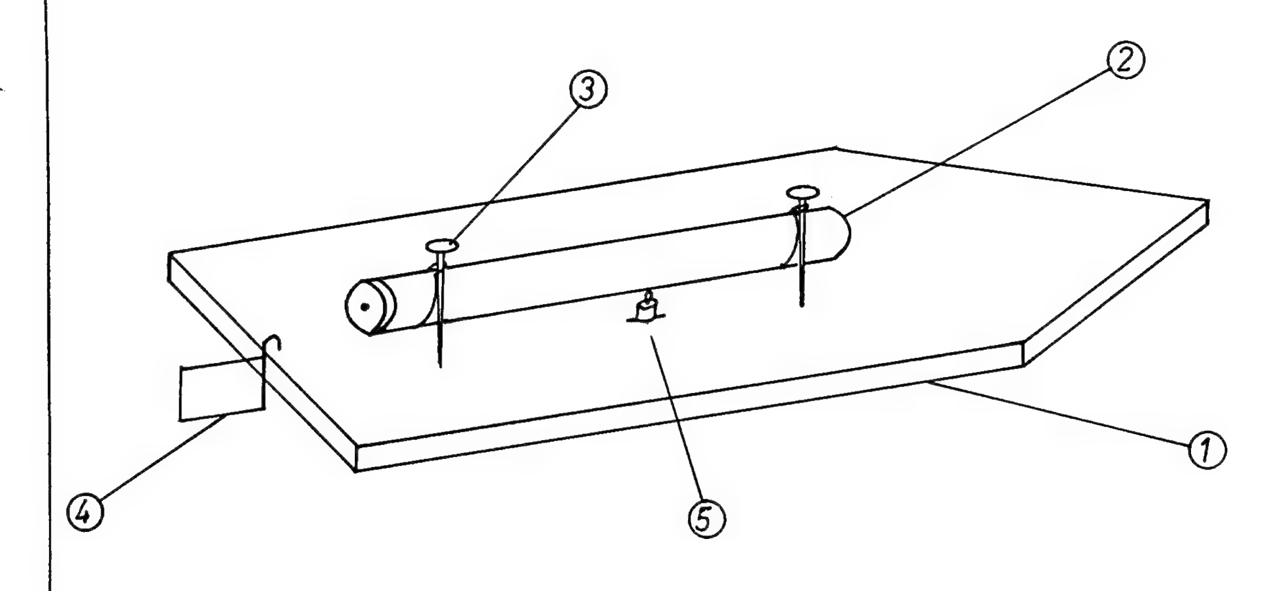


FIG. A.

5- MATERIALS FOR CONSTRUCTION

Components	Qty	Materials Required	Dimensions
1. Float Base.	1.	Wood.	200mm x 80mm x 5mm.
2. Boiler Tube.	1.	Aluminium Cigar Container (or test tube)	approx. 160mm x 20mm.
3. Tube Supports.	2.	Nails.	
4. Rudder.	1.	Plastic Sheet.	approx. 35mm x 25mm.
5. Heat Source.	1.	Small Candle.	
		Copper or Iron Wire.	
		Plasticine.	

Tools: Woodsaw; hammer; long nosed pliers.

6- CONSTRUCTION DETAILS

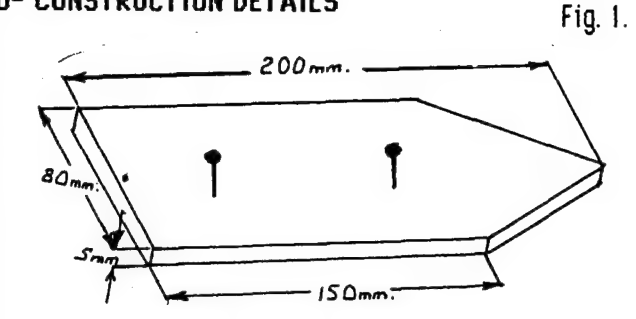


Fig. 1. From a piece of 5mm wood cut out the float shape as indicated in Fig. 1. Insert two nails to act as tube supports approximately 100mm apart, and just off from the centre line such that the centre of the tube would be over the centre line of the float. Make a small hole at the rear of the float to take the rudder support.

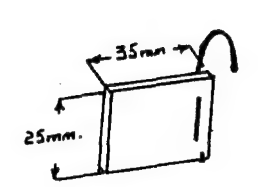


Fig. 2. From a thin piece of plastic sheet cut out the rudder, as shown in Fig. 2. Make two small holes in the side of the rudder and feed through a length of wire as indicated, and shape the rudder support.

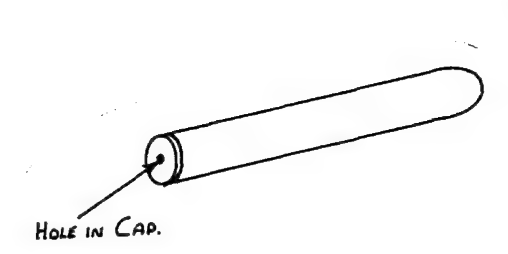


Fig. 3. In the end cap of the aluminium tube pierce a small hole from which the steam will be able to escape.

Using a length of copper or iron wire fix the tube to the tube supports allowing enough space underneath the tube for the candle.

Assemble the float as shown in Fig. A.

7- METHOD OF USE

Pour a small quantity of water into the aluminium tube and replace the lid. Light the candle and then gently place the float onto the surface of a tank of water. As steam is emitted from the hole in the tube the float will be seen to move. The direction of the movement can be varied using the rudder.

8- COMMENTS

Alternative materials such as expanded polystyrene can be used for the float, and a test tube can be used for the tube using a suitable stopper.

1- ITEM

A STEAM TURBINE.

2- PURPOSE

To demonstrate the conversion of heat energy into mechanical (Kinetic) energy.

3- INFORMATION SUBMITTED BY

Pedagogical Academy, Nicosia, Cyprus.

4- LINE DRAWING OF PROTOTYPE

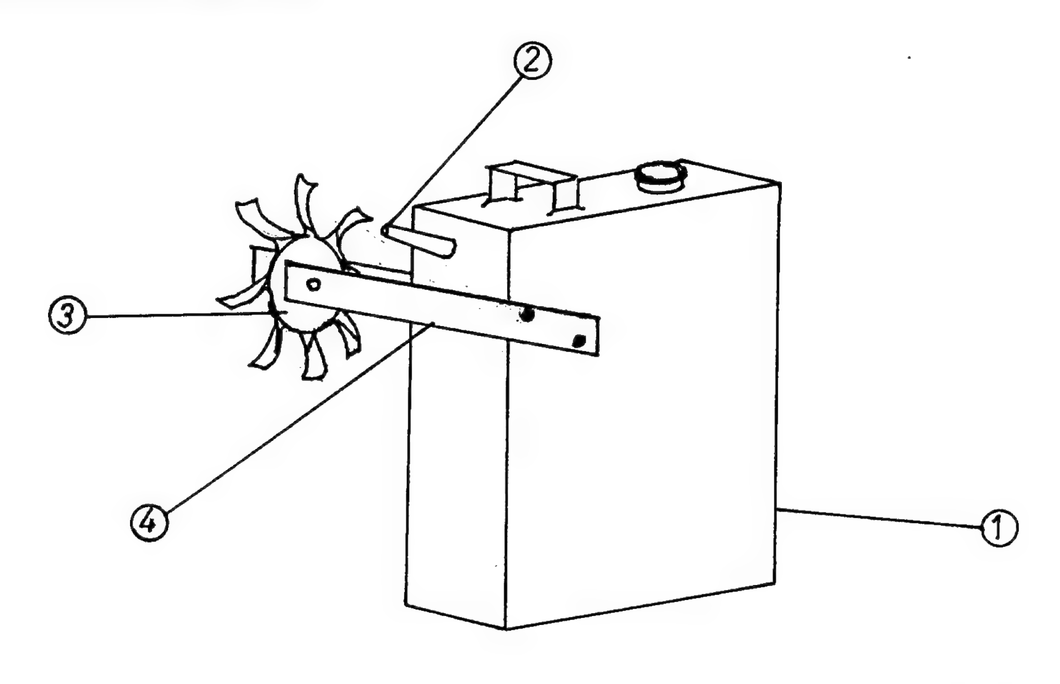


FIG. A.

5- MATERIALS FOR CONSTRUCTION

Components	Qty	Materials Required	Dimensions
1. Container.	1.	Used Oil Can.	as available.
2. Nozzle.	1.	Sheet metal.	approx. 50mm x 15mm x 0.5mm.
3. Rotor.	1.	Typewriter ribbon spool	
	8.	Vanes of sheet metal.	approx. 40mm x 15mm x 1mm.
4. Rotor Support.	2.	Sheet Metal.	200mm x 20mm x 2mm.
		Epoxy resin adhesive.	
		Metal knitting needle (or similar rod).	
		Tools: Tin snips; hacksaw; long nosed pliers; soldering iron and solder.	

6- CONSTRUCTION DETAILS

a

b

Fig. 1.

To construct the rotor obtain a used typewriter ribbon spool, as shown in Fig. 1. a. Using a strip of sheet metal approx. 1mm. thick, cut out eight vanes in the shape shown in Fig. 1. b. Fix the blades into the spool using solder or an epoxy resin adhesive as indicated in Fig. 1. a.

Fig. 2.

From a piece of 0.5mm sheet metal construct a nozzle as indicated in Fig. 2. Punch or drill a hole in the can and attach the nozzle using solder or an epoxy resin adhesive.

100mm

20mm

Fig. 3

Construct two rotor supports from 2mm thick sheet metal, as indicated in Fig. 3. Drill a hole for the rotor spindle in each support. Attach the supports to the can either by soldering or by using an epoxy resin.

7- METHOD OF USE

Pour water into the can until it is approximately two-thirds full. Place the can on a tripod over a heat source. Steam will issue from the nozzle causing the rotor to rotate.

8- COMMENTS

1- ITEM

A MODEL WATER WHEEL.

2- PURPOSE

To demonstrate the transfer of energy as applied to a water wheel.

3- INFORMATION SUBMITTED BY

Beijing Teaching Aids Centre. Hengshui Prefecture. Hebei Province, China

4- LINE DRAWING OF PROTOTYPE

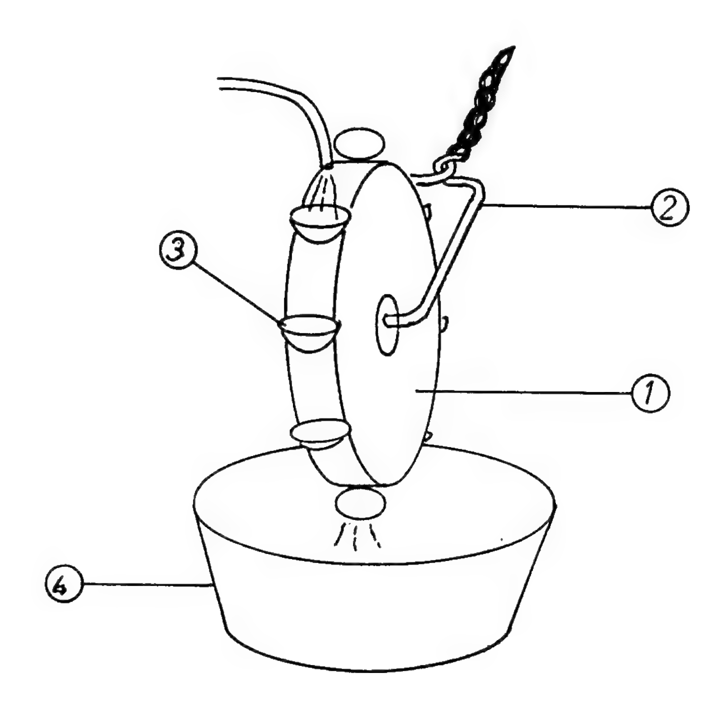


FIG. A.

5- MATERIALS FOR CONSTRUCTION

Components	Qty	Materials Required	Dimensions
1. Wheel.	1.	Wood.	100mm dia. x 10mm.
2. Support.	1.	Iron Wire.	3mm dia. x 400mm.
3. Cups.	8.	Table tennis balls.	
4. Container.	1.	Bowl.	
	8.	Thumb tacks.	

Tools: Woodsaw, compass, pliers, knife, drill and drill bit.

6- CONSTRUCTION DETAILS

100mm.ϕ
10mm.
4mm ϕ.

Fig. 1. From a 10mm thick piece of wood cut out a disc of 100mm diameter. In the centre of the disc drill a 4mm diameter hole, as shown in Figure 1.

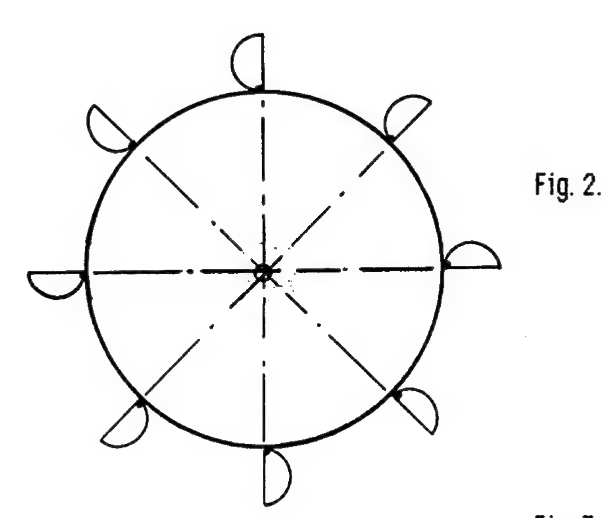


Fig. 2. Take 4 table tennis balls and carefully cut them in half to form 8 cups. Mark out the disc into 8 equal sections and, using small tacks, fit the cups to the rim of the disc, as shown in Fig. 2.

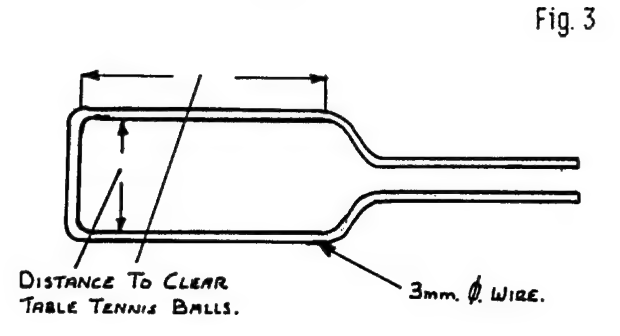


Fig. 3 From a length of stiff iron wire construct the support as indicated in Figure 3. The width and length of the 'U' piece must clear the overall length (dia) and width of the cups on the disc. To ensure that the wheel rotates freely it may be necessary to place spacers either side of the disc. Finally, twist the ends of the wire together to form a handle.

7- METHOD OF USE

Assemble the apparatus as shown in Figure A. Allow water from a tap or other suitable source to flow into the cups and cause the wheel to rotate.

8- COMMENTS

1- ITEM

A MODEL SUBMARINE.

2- PURPOSE

To demonstrate the floating and sinking condition of a body.

3- INFORMATION SUBMITTED BY

Beijing Teaching Aids Centre, Hengshui Prefecture, Hebei Province, China.

4- LINE DRAWING OF PROTOTYPE

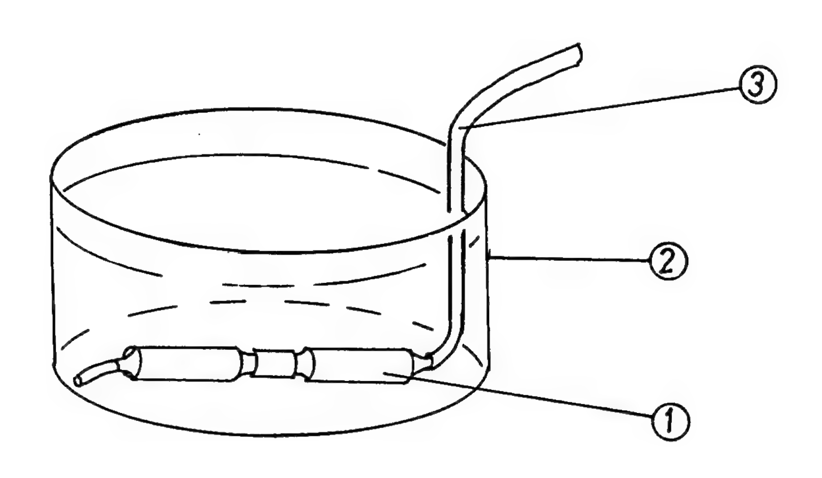


FIG. A.

5- MATERIALS FOR CONSTRUCTION

Components	Qty	Materials Required	Dimensions
1. Submarine.	1.	Glass eye-drop bottles (or phials) - 2	as available.
2. Container.	1.	Glass tank.	as available.
3. Air inlet tube.	1.	Rubber tube.	2mm. i.d. x 400mm
		Adhesive wateproof plaster.	

6- CONSTRUCTION DETAILS

Fig. 1.

JOIN.
RUBBER TUBING
RUBBER TUBING.

Connect two eye-drop bottles head to head using waterproof adhesive tape. Ensure that the seal is airtight.

Connect a short length of the rubber tubing to one end of the "submarine" and the longer length of tubing to the other end.

7- METHOD OF USE

Pour water into the glass tank and lower the "submarine" onto the water where it should just float. Allow water to enter by sucking air out through the long tube, and the "submarine" will sink to the bottom. Force water out, by blowing down through the rubber tube, and the "submarine" will rise to the surface.

8- COMMENTS

1- ITEM

A MODEL ROCKET.

2- PURPOSE

To demonstrate the principle of action and reaction and its application to rockets.

3- INFORMATION SUBMITTED BY

Beijing Teaching Aids Centre, Hengshui Prefecture, Hebei Province, China.

4- LINE DRAWING OF PROTOTYPE

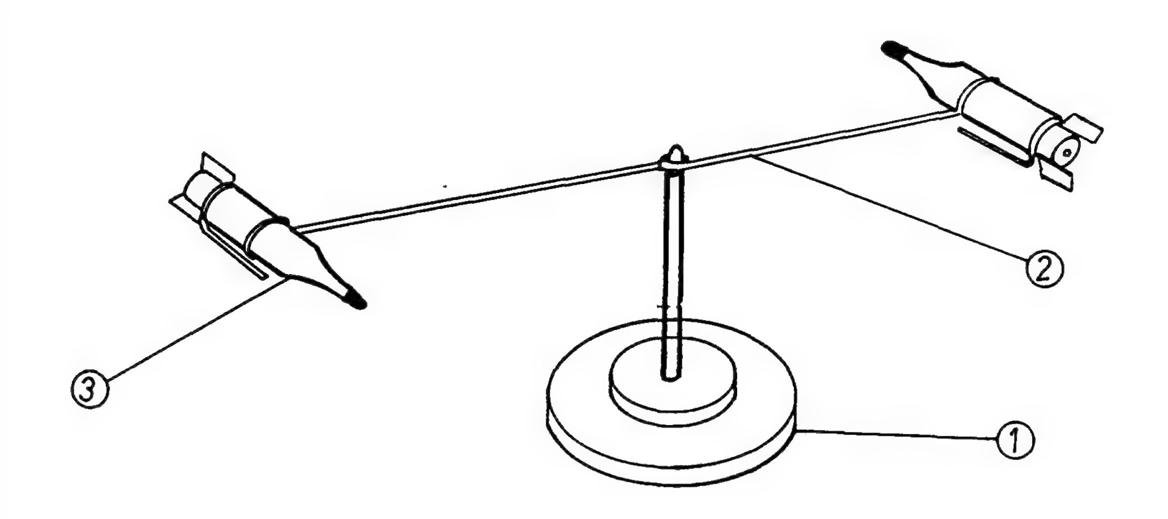


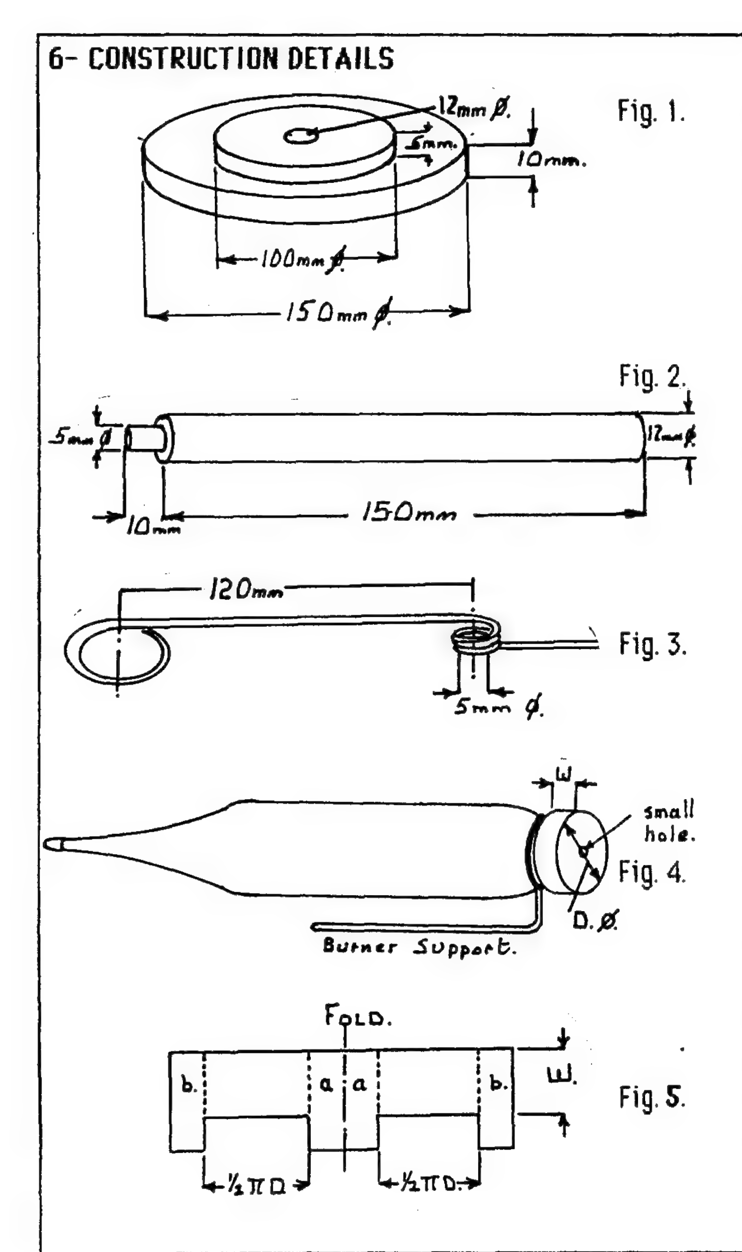
FIG. A.

5- MATERIALS FOR CONSTRUCTION

Components	Qty	Materials Required	Dimensions
1. Base and support.	1.	Wood (discs and rod).	as available
2. Rotor Arm.	1.	Copper or iron wire.	approx: 1mm dia x 200mm
3. Rocket.	2.	Glass eyedrop bottles (with rubber caps).	as available.
		Metal sheet	approx: 0.3mm thick.
		Cotton Balls.	
		Glue.	

Tools: Woodsaw, pliers, tin snips (or scissors), drill and drill bit.

6- CONSTRUCTION DETAILS



From a piece of 15mm thick timber construct a base as shown in Fig. 1. Drill a 12mm diameter hole through the centre.
Using a piece of 12mm diameter wood dowelling make a support rod as shown in Fig. 2. Form the spigot at one end by reducing the diameter to 5mm.

From a length of stiff copper or iron wire construct a rotor arm as shown in Fig. 3. The diameter of the loops at each end should provide a firm grip on the eye drop bottles (rockets). The coil at the centre between the two loops should be able to freely rotate on the spigot of the support rod.

Obtain two discarded eye drop bottles (with rubber and caps). Make a very small hole in the centre of each end cap.
From a length of copper or iron wire attach a burner support as shown in Fig. 4.

Using D = diameter of end cap and
W = width of end cap (Fig. 4.) mark out the fins for the rocket (as shown in Fig. 5) on a thin piece of metal sheet (foil). To construct the fins fold at the centre and glue 'a.a.' together and 'b.b.' together. When firmly glued slide the centre portion over the cap.
Assemble the apparatus as shown in Fig. A.

7- METHOD OF USE

Pour an amount of hot water into the bottles and place some cotton wool on the burner support. Pour some alcohol into the cotton and ignite it. As the water boils steam will be emitted from the small hole in the end caps of the bottles and the rockets will rotate.

8- COMMENTS

1- ITEM

A SIMPLE FIRE EXTINGUISHER.

2- PURPOSE

To demonstrate how a chemical reaction produces foam which will extinguish a fire.

3- INFORMATION SUBMITTED BY

Beijing Teaching Aids Centre, Hengshui Prefecture, Hebei Province, China.

4- LINE DRAWING OF PROTOTYPE

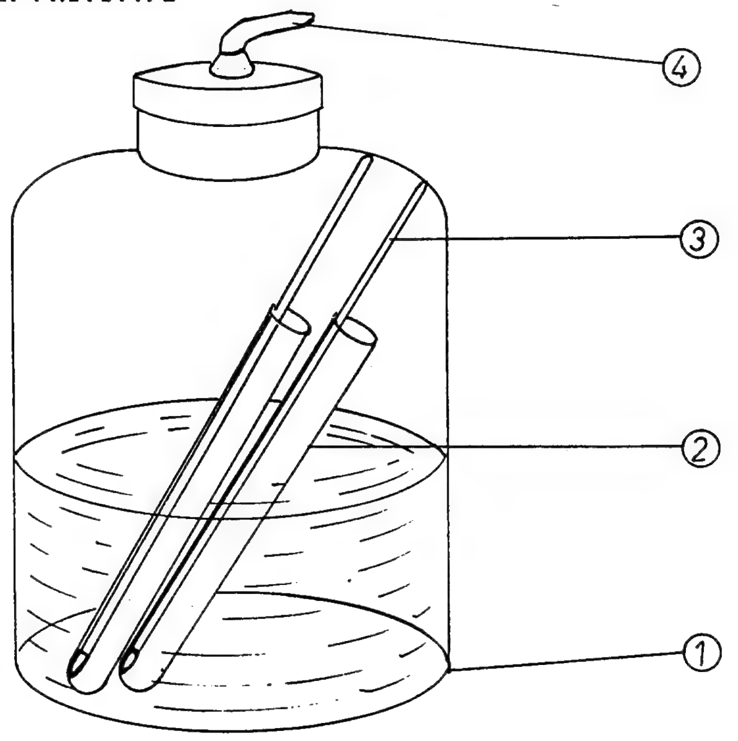


FIG. A.

5- MATERIALS FOR CONSTRUCTION

Components	Qty	Materials Required	Dimensions
1. Container.	1.	Glass Bottle (wide mouth).	approx. 1 litre.
2. Test tubes.	2.	Glass test tubes.	16mm x 160mm.
3. Tube stays.	2.	Glass rods.	4mm dia. x 220mm.
4. Spray nozzle.	1.	Glass tube.	7mm. o.d. x 60mm
	2.	Rubber caps for rods.	
		Washing powder.	approx. 15g.
		$NaHCO_3$	approx. 30g.
		$KAl(SO_4)_2$	approx. 10g.

6- CONSTRUCTION DETAILS

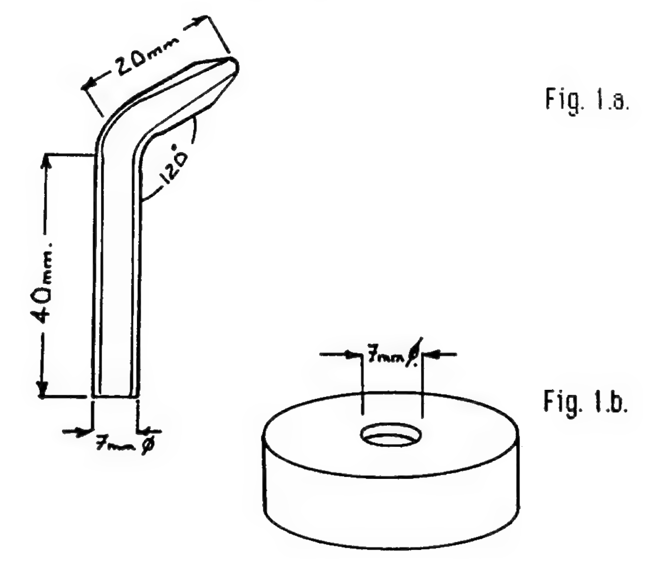
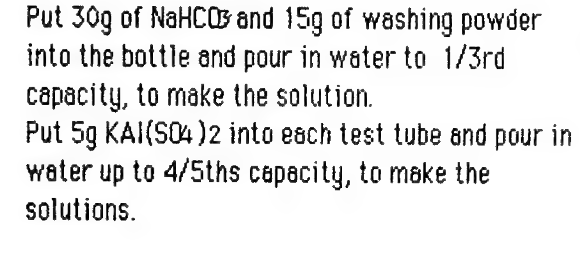


Fig. 1.a.

Bend the glass tube to the shape and size shown in Fig. 1. a. Draw out the shorter arm to give a bore size of 3mm. diameter.

Drill a 7mm diameter hole in the lid of the bottle (Fig. 1.b) Insert the glass tube and seal it into the lid using an epoxy resin adhesive (or other suitable sealant).

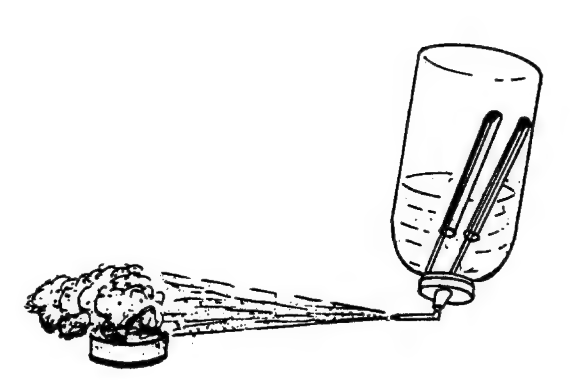
Fig. 1.b.



Put 30g of $NaHCO_3$ and 15g of washing powder into the bottle and pour in water to 1/3rd capacity, to make the solution.

Fig. 2.

Put 5g $KAl(SO_4)_2$ into each test tube and pour in water up to 4/5ths capacity, to make the solutions.



On the end of each of the two glass rods place a rubber bumper. Place the rods, bumper end down, in each of the test tubes.

Carefully lower each of the test tubes with rods into the bottle taking care not to spill the solutions.

Place the lid (with nozzle attached) onto the bottle.

7- METHOD OF USE

Obtain a metal box and place some paper and cotton waste in the box. Set light to this waste material. Turn the bottle upside down and point the spray head at the fire. Foam, produced by the chemical reaction in the bottle, will be emitted from the nozzle and extinguish the fire. (Fig. 2.)

8- COMMENTS

1- ITEM

EXPLOSION APPARATUS.

2- PURPOSE

To demonstrate the explosive nature of fine powder.

3- INFORMATION SUBMITTED BY

Beijing Teaching Aids Centre, Hengshui Prefecture, Hebei Province, China.

4- LINE DRAWING OF PROTOTYPE

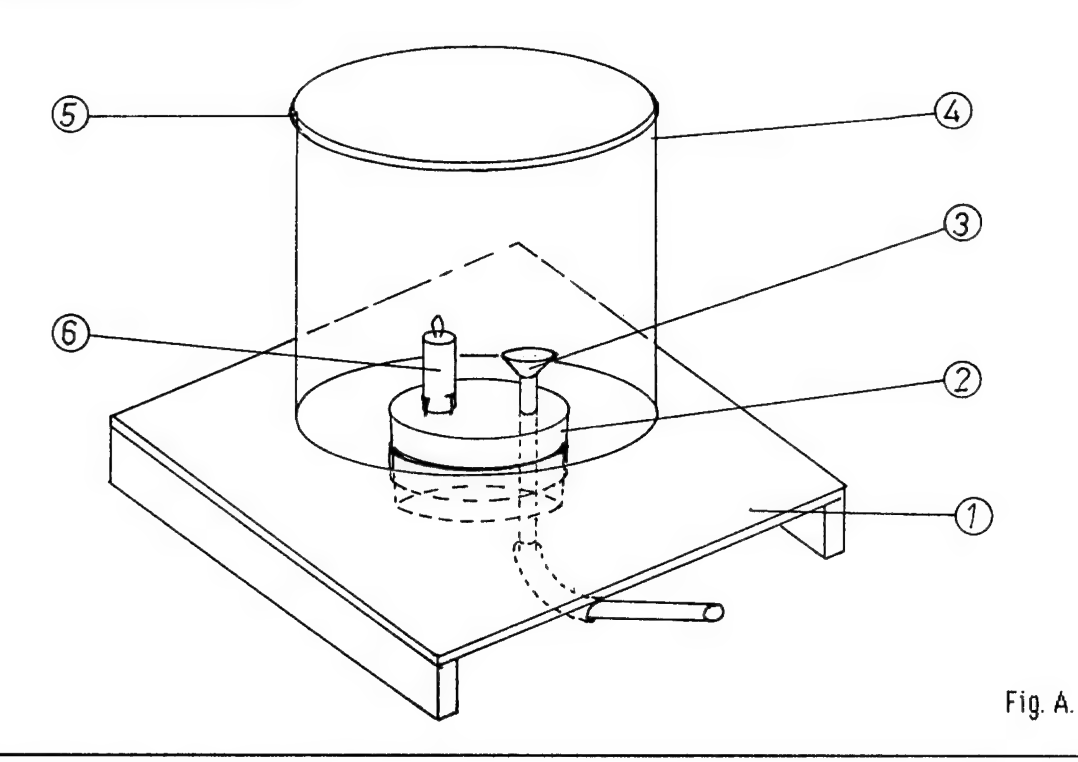
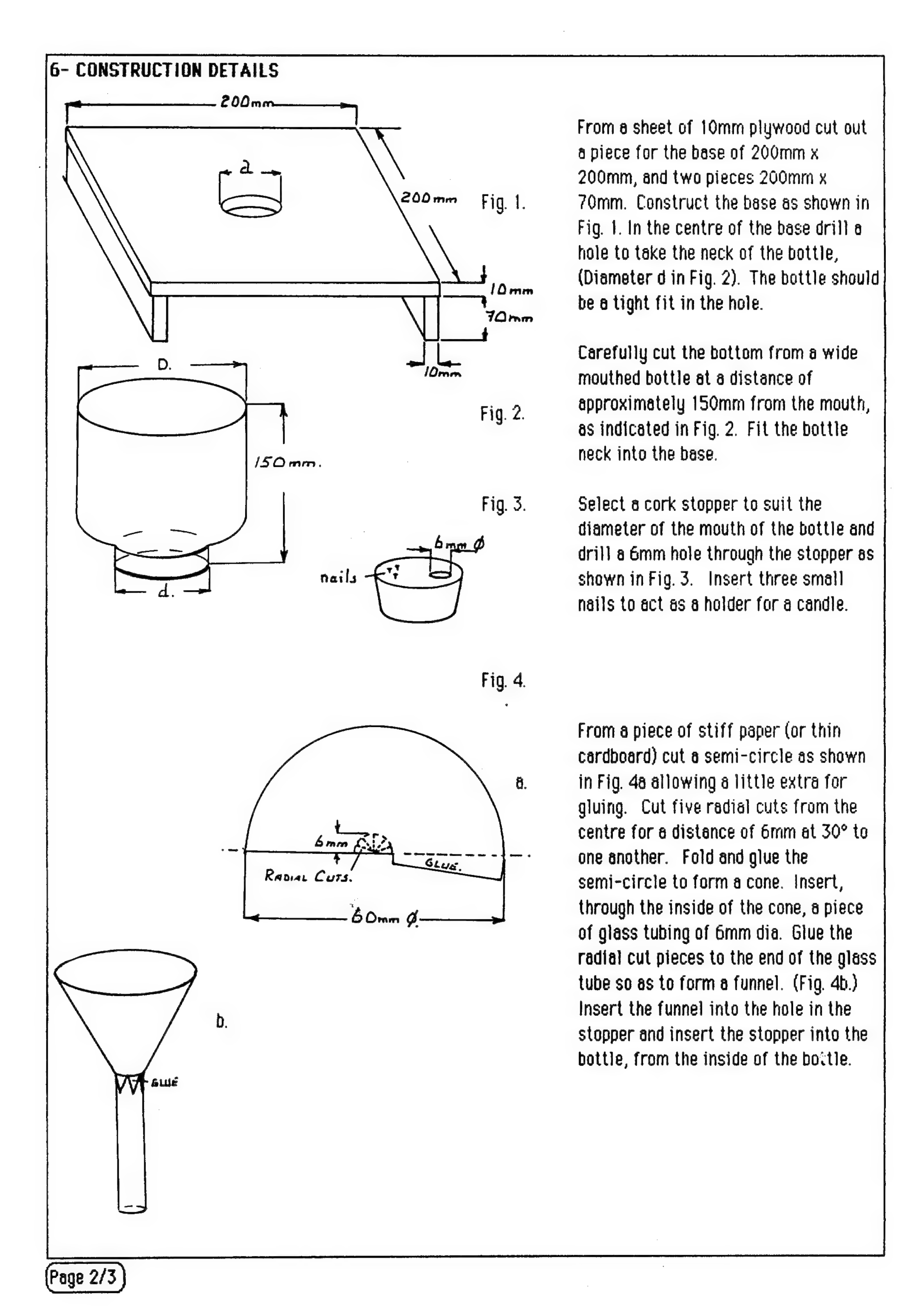


Fig. A.

5- MATERIALS FOR CONSTRUCTION

Components	Qty	Materials Required	Dimensions
1. Base.	1.	Plywood (1 piece).	200mm x200mm x 10mm
		Plywood (2 pieces).	200mm x 70mm x 10mm
2. Stopper.	1.	Rubber or Cork Stopper.	to suit bottle.
3. Funnel.	1.	Stiff Paper or Cardboard.	60mm x 40mm
4. Container.	1.	Bottle, large with wide mouth	as available.
5. Container Lid.	1.	Plywood.	3mm thick.
6. Candle.	1.	Wax Candle.	approx: 5cm long.
	1.	Glass tube.	6mm o.d. x 35mm long
	1.	Rubber tube.	6mm i.d. x 1m. long.
	1.	Clay Ball.	6mm dia.
	3	Nails, small	
		Tools: Woodsaw, hammer, nails, scissors, cork borer, drill and drill bits.	

6- CONSTRUCTION DETAILS



From a sheet of 10mm plywood cut out a piece for the base of 200mm x 200mm, and two pieces 200mm x 70mm. Construct the base as shown in Fig. 1. In the centre of the base drill a hole to take the neck of the bottle, (Diameter d in Fig. 2). The bottle should be a tight fit in the hole.

Carefully cut the bottom from a wide mouthed bottle at a distance of approximately 150mm from the mouth, as indicated in Fig. 2. Fit the bottle neck into the base.

Select a cork stopper to suit the diameter of the mouth of the bottle and drill a 6mm hole through the stopper as shown in Fig. 3. Insert three small nails to act as a holder for a candle.

From a piece of stiff paper (or thin cardboard) cut a semi-circle as shown in Fig. 4a allowing a little extra for gluing. Cut five radial cuts from the centre for a distance of 6mm at 30° to one another. Fold and glue the semi-circle to form a cone. Insert, through the inside of the cone, a piece of glass tubing of 6mm dia. Glue the radial cut pieces to the end of the glass tube so as to form a funnel. (Fig. 4b.) Insert the funnel into the hole in the stopper and insert the stopper into the bottle, from the inside of the bottle.

6- CONSTRUCTION DETAILS (Continued)

Complete the assembly of the apparatus by inserting a candle and fixing it in position by the nails; and also drop a 6mm dia clay ball into the funnel to act as a valve. Finally, connect a length of rubber tubing to the end of the funnel and cover the bottle with a thin wooden cover slightly larger than diameter D (Fig. 2.).

7- METHOD OF USE

Use fine, dry, flour for the purposes of the explosion demonstration. Remove the cover and add a little flour into the funnel. Light the candle and replace the cover. Through the length of rubber tube give a short puff of air to blow the flour out of the funnel. An explosion will then take place.

8- COMMENTS

For safety purposes this demonstration should be carried out behind a safety screen. Do not fix the lid to the bottle since it must be able to fly off if the explosion is too great.

1- ITEM

CAPILLARY ACTION APPARATUS.

2- PURPOSE

To demonstrate capillary action.

3- INFORMATION SUBMITTED BY

Beijing Teaching Aids Centre, Hengshui Prefecture, Hebei Province, China.

4- LINE DRAWING OF PROTOTYPE

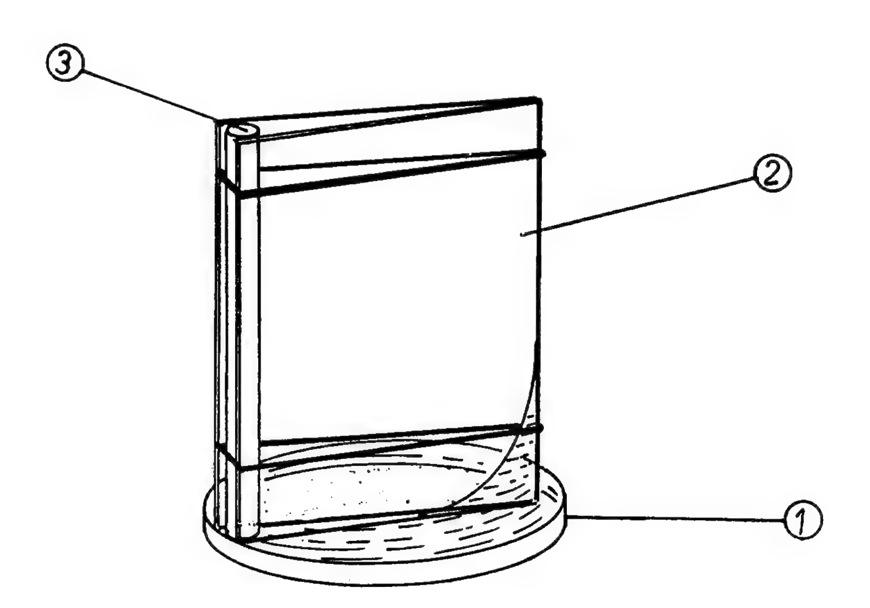


FIG. A.

5- MATERIALS FOR CONSTRUCTION

Components	Qty	Materials Required	Dimensions
1. Dish.	1.	Shallow dish or bowl	approx. 20cm. dia.
2. Glass Plates.	2.	Glass plate.	approx. 20cm x 25cm.
3. Separator.	1.	Wooden Rod.	less than 5mm dia.
	2.	Rubber bands (large)	

6- CONSTRUCTION DETAILS

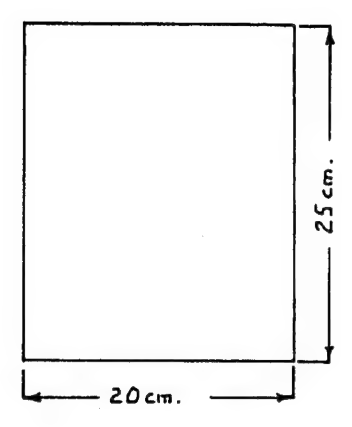


Fig. 1.

Cut two pieces of plate glass to the same size. Remove the sharp edges except for the two edges which will be in contact.



Fig. 2.

Insert the separator as shown in Fig. 2. and clamp the arrangement together using two rubber bands.

Note: If there is no capillarity when first used replace the separator with a thinner one so as to reduce the angle between the two glass plates.

7- METHOD OF USE

Place a small amount of water in the dish. Stand the unit in the water and observe the result of the capillary action. This can be explained as equating to a series of thin tubes differing from one to the next by their diameter.

8- COMMENTS

The size indicated is suitable for demonstration purposes. Student-use sets could be made using old glass photographic plates.

1- ITEM

A WATER FILTER.

2- PURPOSE

To filter water.

3- INFORMATION SUBMITTED BY

Pedagogical Academy, Nicosia, Cyprus.

4- LINE DRAWING OF PROTOTYPE

FIG . A.

5- MATERIALS FOR CONSTRUCTION

Components	Qty	Materials Required	Dimensions
1. Base.	1.	Wood.	200mm x 150mm x10mm
2. Filter Vessel.	1.	Glass Bottle.	
3. Support.	1.	Wood.	300mm x 20mm x 20mm.
4. Filter Media.		Small stones	
5. Filter Media.		Charcoal	
6. Filter Media.		Sand	
7. Filter Media.		Fine Sand	
8. Filter Media.		Cotton Wool	
9. Stopper.	1.	Rubber Bung.	To suit dia. of bottle.
10. Tube.	1.	Glass Tube.	approx 3mm i.d. x 5cm.
11. Container.	1	Glass trough.	as available.
		Iron Wire.	as available.

Tools: Woodsaw; cork borer glass cutter (or old file)pliers; hammer; nails; drill and drill bits, small chisel.

6- CONSTRUCTION DETAILS

200mm

20mm

150mm

10mm

20mm

20mm

20mm

Fig. 1. Take the bottle and, using a glass cutter or old file, score a line around the bottle near the base. As neatly as possible break off the base (a red hot tip of metal placed on the score line may do this) and remove the sharp edges (using the old file or by rubbing on concrete).

Fig. 2. Construct a base as shown in Fig. 1. Using the drill and a small chisel cut out the hole for the support.

Prepare the support using a piece of 20mm x 20mm wood. The length will depend upon the size of the bottle used. Using glue and nails firmly fix the support into the hole in the base.

Fig. 3. Bore a hole in the rubber bung and insert a small length of glass tubing. Fit the bung into the bottle.
Fill the bottle with the filter materials and wire it to the support as shown in Fig. A.

7- METHOD OF USE

Pour impure water into the open top of the bottle and, after a short time, clear water will be seen to be dripping into the container.

8- COMMENTS

Wear eye goggles when cutting glass.

A plastic bottle can also be used for this apparatus.

1- ITEM

NEWTON'S DISC APPARATUS.

2- PURPOSE

To observe that the colour "White" is made up from a mixture of seven colours.

3- INFORMATION SUBMITTED BY

Pedagogical Academy, Nicosia, Cyprus.

4- LINE DRAWING OF PROTOTYPE

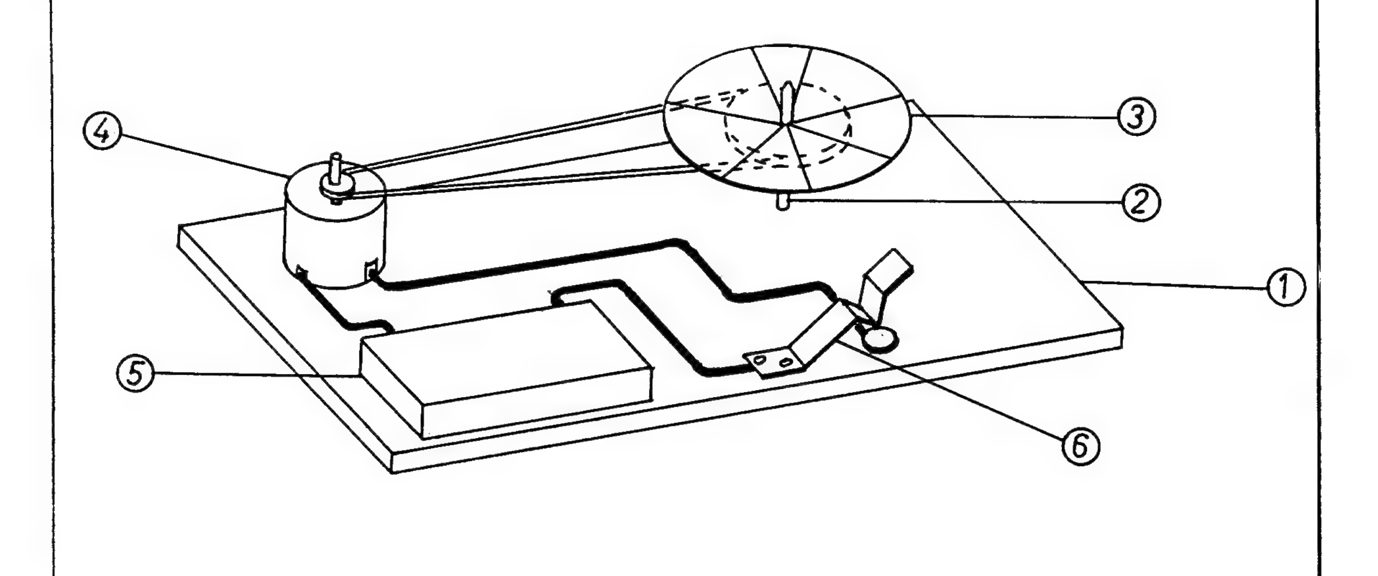


Fig. A.

5- MATERIALS FOR CONSTRUCTION

Components	Qty	Materials Required	Dimensions
1. Base.	1.	Wood.	250mm x 150mm x 10mm.
2. Spindle.	1.	Wood.	5mm dia;
3. Disc.	1.	Cardboard.	approx. 100mm dia.
4. Motor.	1.	6 volt electric motor.	
5. Power supply.	1.	6 volt Battery.	
6. Switch.	1.	Sheet metal strip.	10mm wide x 1mm thick.
		Insulated copper wire.	
		Drawing pin.	
		Rubber band.	
		White paper.	
		Colours.	
		Adhesive.	
		Tools: Woodsaw; pliers; tin snips; drill and drill bits;	

6- CONSTRUCTION DETAILS

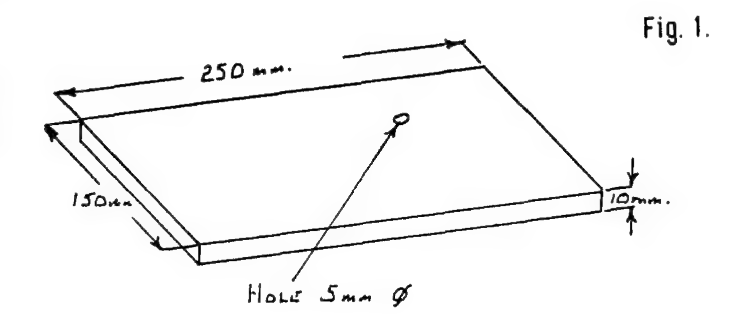


Fig. 1.

From a sheet of 10mm thick wood construct a base of size 250mm x 150mm. Drill a 5mm dia. hole for the spindle as indicated in Fig. 1.

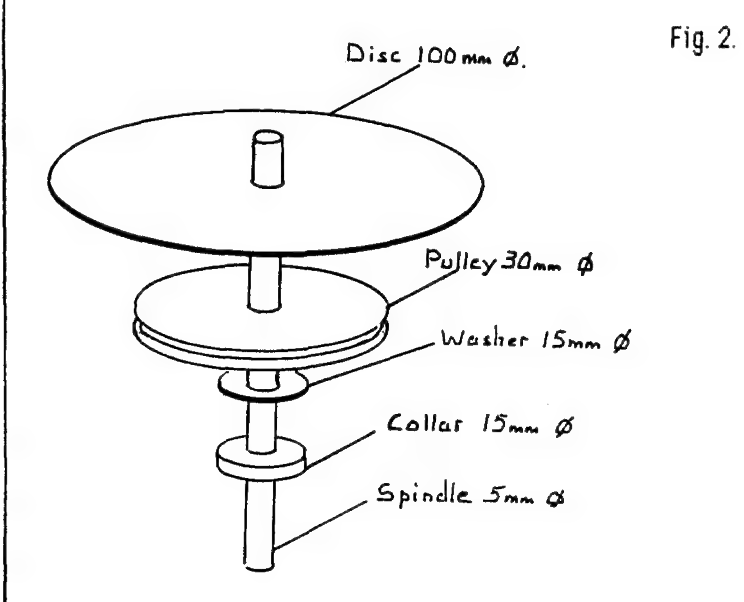


Fig. 2.

Use a 5mm dia. piece of round wood (dowel) as a spindle. Cut the length as required. Make a 5mm dia. hole in the base, in a suitable position, and glue the spindle into the hole.
From a 15mm dia. piece of wood cut off a length of 10mm and drill a 5mm dia. hole through this disc to make a collar. At a suitable height (depending upon the height of the pulley on the motor). Fix the collar to the spindle. Place a metal washer onto the collar so that the pulley will rotate freely.
Obtain (or make) a pulley of approx. 30mm diameter. The hole in the centre should be large enough for the pulley to rotate freely on the spindle.
From a piece of stiff cardboard cut out a disc. of approx. 100mm dia. Glue a 100mm dia. piece of white paper to the cardboard disc. Drill a suitable hole in the disc and glue the disc to the pulley. (See 'Comments' below regarding colouring of the disc).
The complete arrangement is shown in Fig. 2.

6- CONSTRUCTION DETAILS (Continued)

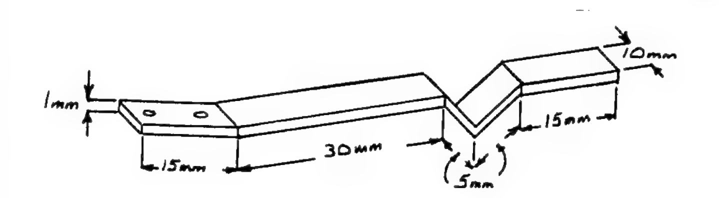


Fig. 3. From a 10mm x 1mm thick piece of strip steel construct a switch as shown in Fig. 3. Use a drawing pin as the second contact.

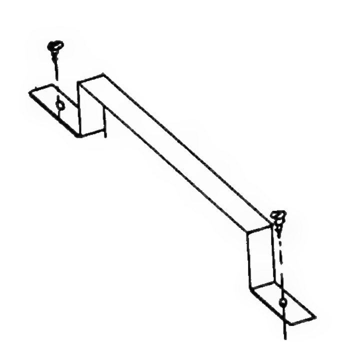


Fig. 4. From a similar piece of strip steel construct a clamp for holding the battery, as shown in Fig. 4.

From an, old cassette tape recorder remove the motor and its pulley and fix it to the base in a suitable position.

Assemble the apparatus as shown in Fig. A.

7- METHOD OF USE

Having assembled the apparatus close the switch and the disc will rotate. The colours gradually blur as the speed builds up until the disc appears to be a grey-white colour. (Pure white cannot be obtained due to the impurities in the colours used and the proportions of each coloured segment on the disc).

8- COMMENTS

To make Newton's Coloured Disc divide the disc into 7 segments. Colour the first segment red, the second orange, the third yellow; and so on around in a clockwise direction. The seven colours being red, orange, yellow, green, blue, indigo and violet.

1- ITEM

A PIAGETIAN INSTRUMENT.

2- PURPOSE

To investigate a child's perception about the states in a transformation at the pre-operational stage of development.

3- INFORMATION SUBMITTED BY

Pedagogical Academy, Nicosia, Cyprus.

4- LINE DRAWING OF PROTOTYPE

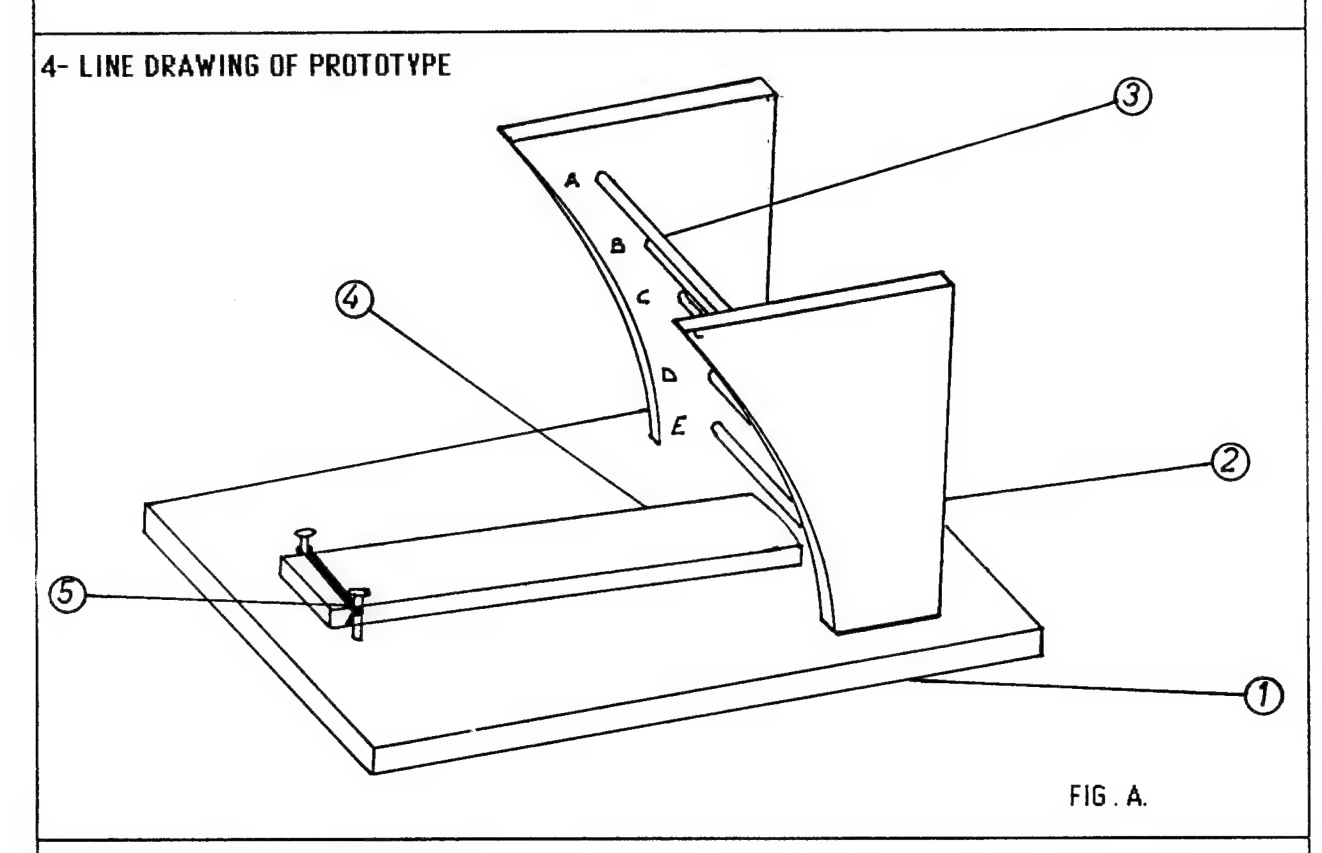


FIG. A.

5- MATERIALS FOR CONSTRUCTION

Components	Qty	Materials Required	Dimensions
1. Base.	1.	Wood.	200mm x 150mm x 10mm.
2. Support.	2.	Wood.	120mm x 60mm x 10mm.
3. Rods.	5.	Wood.	5mm dia. x 100mm.
4. Lever.	1.	Wood.	120mm x 20mm x 6mm.
5. Hinge.	1.	Rubber Band.	
	2.	Nails.	
		Adhesive.	

Tools: Woodsaw; hammer; drill and drill bits; small chisel;

6- CONSTRUCTION DETAILS

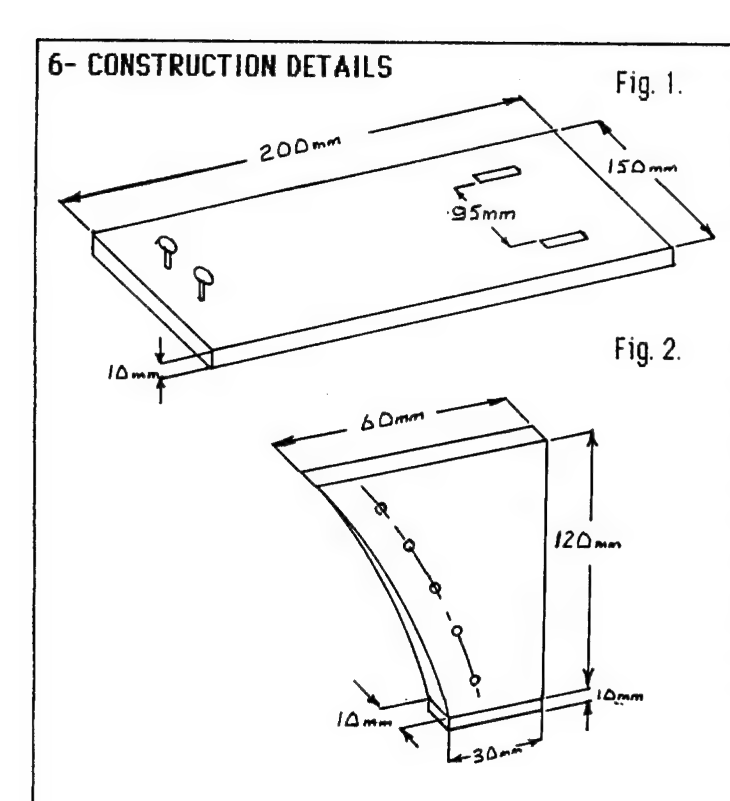


Fig. 1. Construct the base board from a sheet of 10mm thick plywood. Using a drill and small chisel cut out two slots as indicated in Fig. 1. Insert two nails into the board to act as the hinge supports for the lever.

Fig. 2. Prepare two supports from a sheet of 10mm plywood as shown in Fig. 2.
Drill five 5mm dia. holes in each of the supports to take the rods. These holes should be drilled in a curve such that the lever would be able to rest on each rod. Cut the five rods to a length of 100mm each. Insert them into the holes in the two supports and glue them in place.
Insert the supports into the slots in the base and glue in place.

Fig. 3. Construct the lever from a piece of 6mm plywood. Slightly curve the ends which will rest on the rods.

Assemble the apparatus as shown in Fig. 1. Use a rubber band as a hinge for the lever.

7- METHOD OF USE

The lever can be moved to rest on each of the rods. If a pre-operational stage child is shown the experiment, after having been informed he will be asked to draw a diagram of it, the child's drawing is likely to indicate only positions 'a' and 'e'. At this stage of development it is unlikely that the child will observe and record the intermediate transformations and only be concerned with the first and final positions of the lever.

8- COMMENTS

PART II

1- ITEM

MAGNETIC STIRRER.

2- PURPOSE

A simple magnetic stirrer for the observation of heat of solutions and titration.

3- INFORMATION SUBMITTED BY

Kyoto Municipal Science Center for Youth, Kyoto 612, Japan.

4- LINE DRAWING OF PROTOTYPE

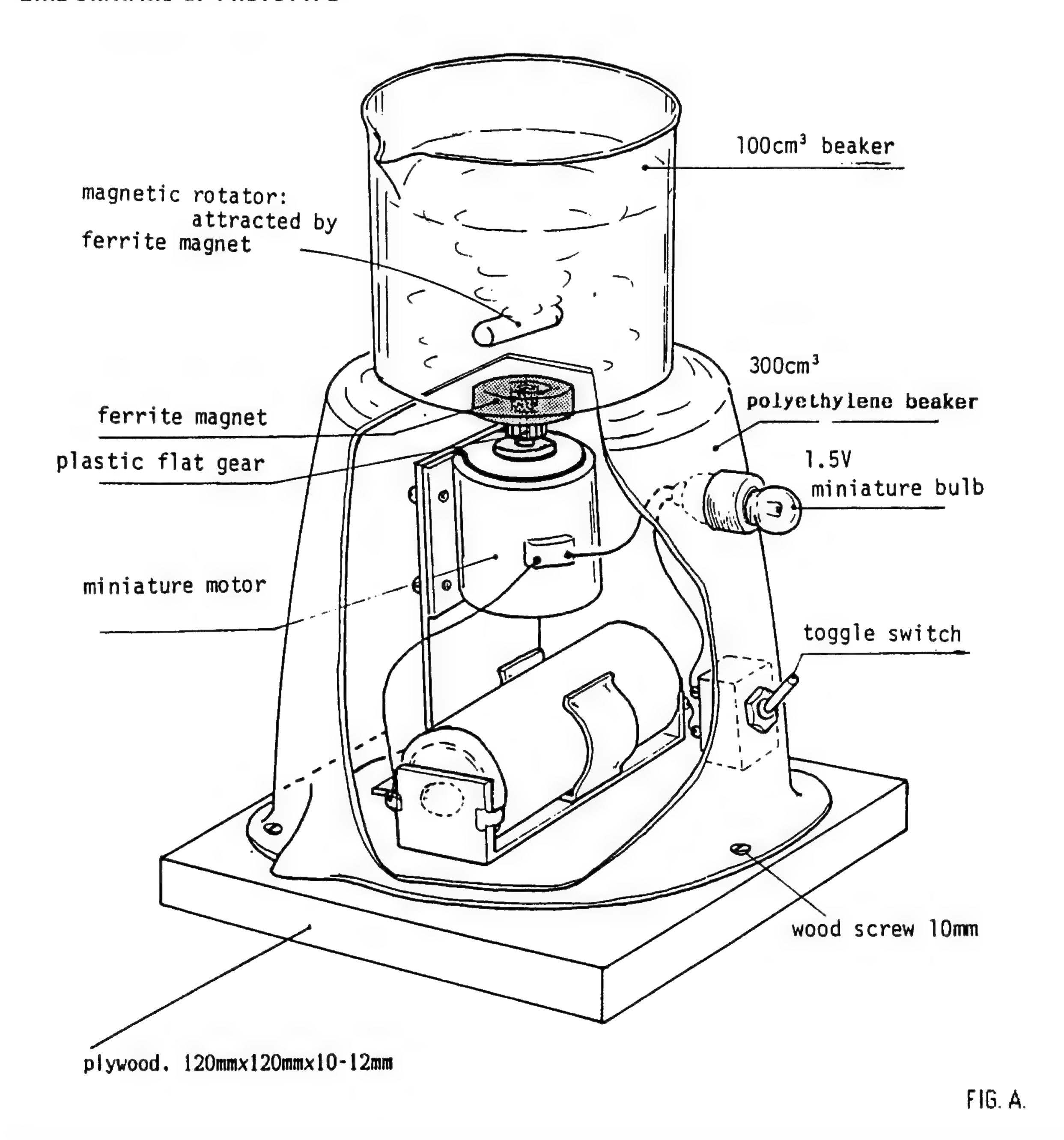


FIG. A.

5- TOOLS AND MATERIALS

(TOOLS)

Double -Edged Saw
Electric Hand Drill
Drill Bit (dia. 3mm)
Tin Snips
Metal Pipe
Iron Rod.
Electric Soldering Iron
Screw Driver

(MATERIALS)

Multi-Strand Insulated Electrical Wire (20cm in length)
Brass Plate (10mm x 100mm x 0.5mm)
Plywood (120mm x 120mm x 10mm)

Miniature Motor with Holder.........1
Dry Cell (1.5V) with Holder.........1
Toggle Switch.........1
Miniature Bulb. (1.5V).........1
Miniature Socket.........1
Polyethylene Beaker (500ml).........1
Ferrite Magnet.........1
Flat Gear of Plastic (dia. 15mm).........1
Stirring Magnet.........1
Bolt and Nut (dia. 3mm).........1
Screw (10mm in length).........1

6- CONSTRUCTION DETAILS

Details on page 3.

0- CONSTRUCTION DETAILS (Continued)

(DETAILS)

(1) As shown in Fig. 1, fix the flat plastic gear on to the axis of the miniature motor (which is set onto its holder vertically), and secure the ferrite magnet disc onto it. Use such a magnet where the S pole shares half the disc and N pole shares the other half.

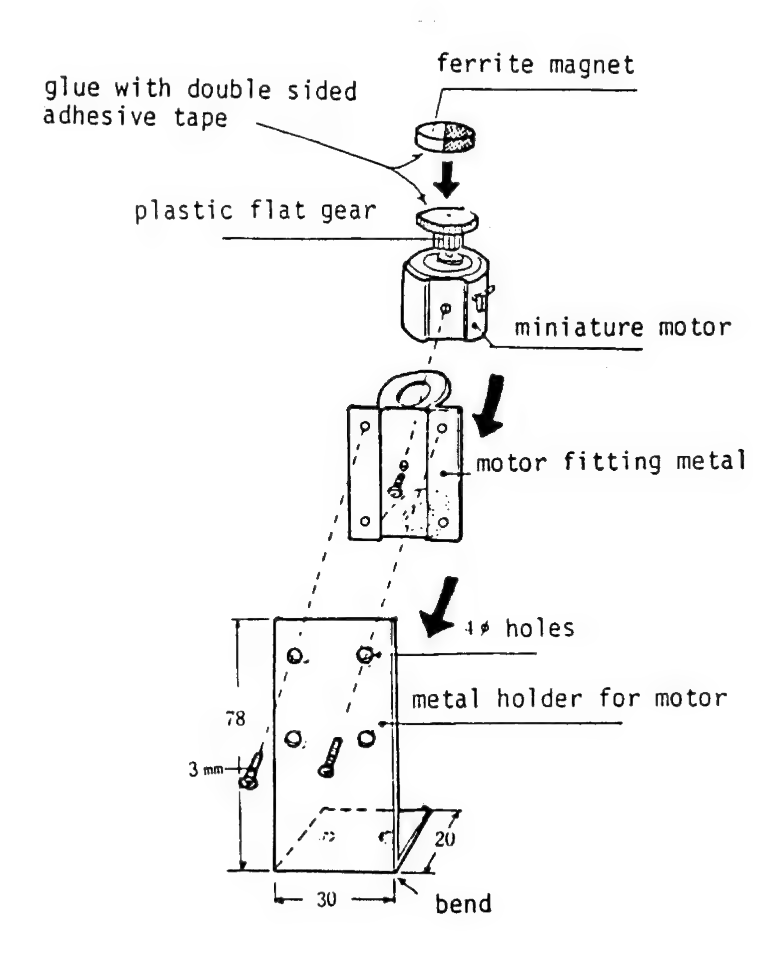


Fig. 1.

(2) Connect the miniature motor to its support as shown in Fig. 1.

6- CONSTRUCTION DETAILS (Continued)

(3) Complete the unit as shown in Fig. 2.

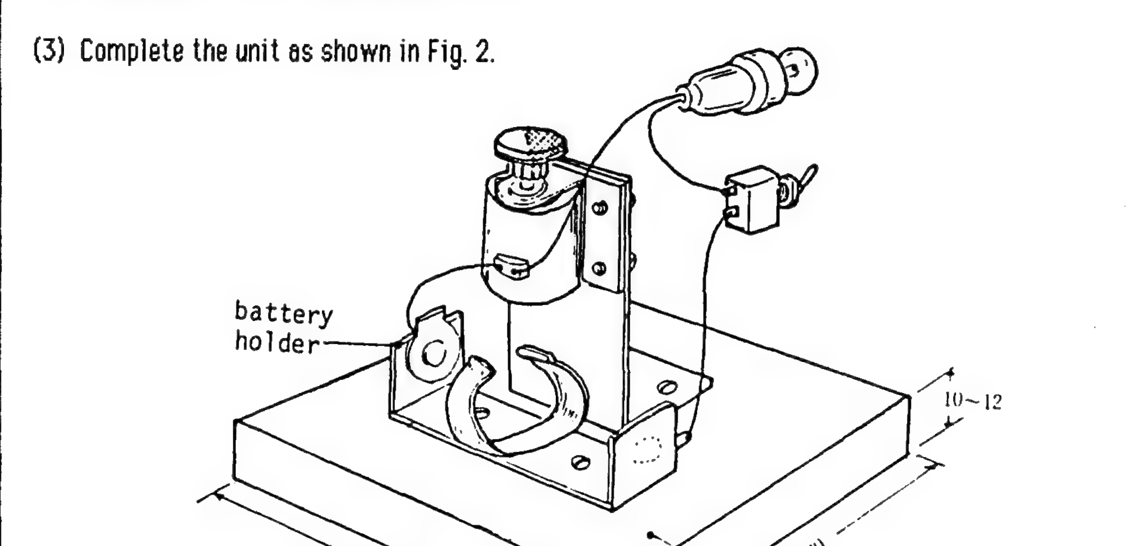


FIG. 2.

(4) Make a hole with a heated metal pipe or rod as shown in Fig. 3.

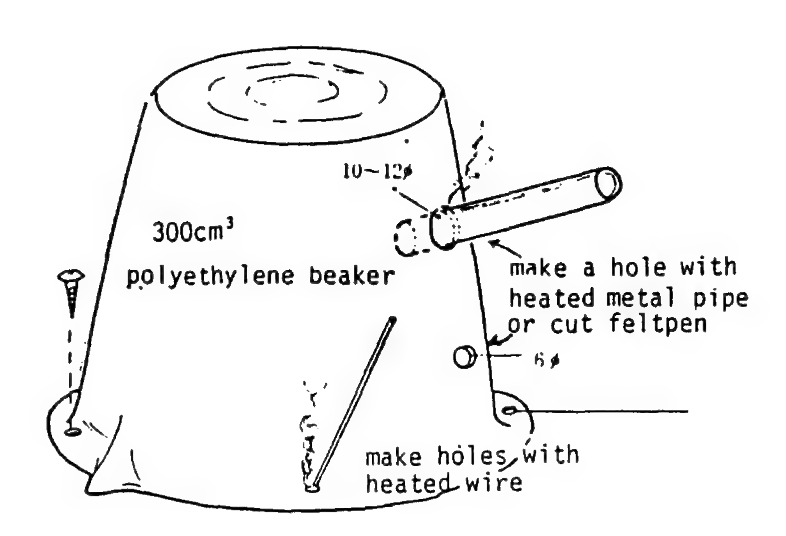


Fig. 3.

(5) Put the polyethylene beaker upside down over the motor assemblage, not touching the ferrite magnet. Thus the main body has been constructed.

7- METHOD OF USE

Place a beaker containing water and the magnetic rotator (Teflon-covered magnetic rod) on top of the magnetic stirrer as shown in Fig. A. By magnetic interaction the rotating ferrite magnet causes the rotator in the liquid to rotate thereby stirring the liquid. The speed of rotation can be varied using a higher voltage lamp in the lamp holder (i.e. changes the resistance of the circuit).

(i) TO OBSERVE THE HEAT OF DISSOLUTION.
Place a beaker with a known amount of water onto the stirrer. Add a rotator into the water. Dip a thermometer into the water and hold it vertically. Note the temperature. Switch on the stirrer. Dissolve a known amount of solid substance such as sodium hydrogen; sodium chloride; sodium chloride; sodium thio sulfate or ammonium acetate. Record the thermometer reading every 10 seconds. Find the maximum and minimum temperatures. The difference of each from the initial temperature is a measure of the heat evolved or absorbed by dissolution.

(ii) TITRATION.
Titration using reactions such as neutralisation, oxidation, and complex-formation, can conveniently be done using this apparatus.

1- ITEM

MAGNETIC FIELD APPARATUS.

2- PURPOSE

To observe the magnetic field around a magnet.

3- INFORMATION SUBMITTED BY

Kyoto Municipal Science Center for Youth, Kyoto 612, Japan.

4- LINE DRAWING OF PROTOTYPE

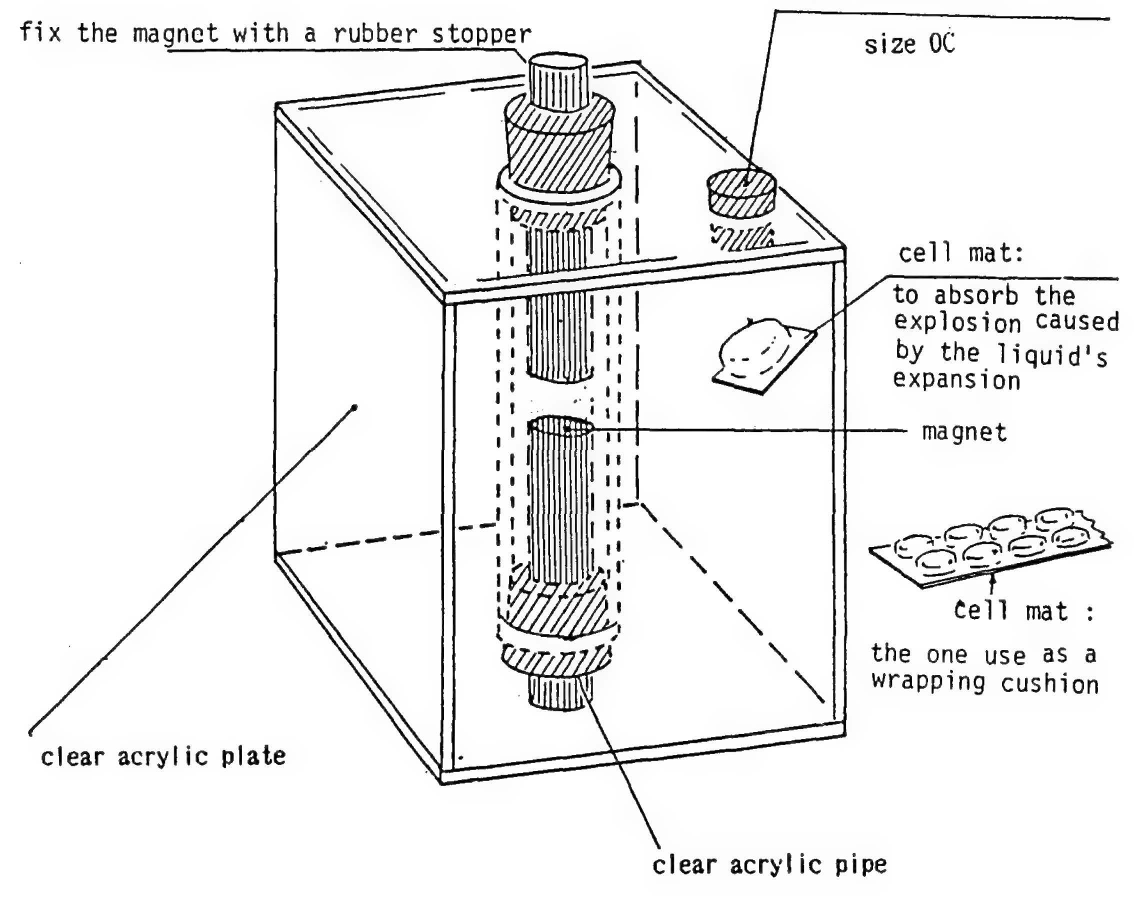


FIG. A.

5- TOOLS AND MATERIALS

(TOOLS)
Cutter for Plastics
Electric Hand Drill
Drill Bit (dia. 17mm)
Drill Bit (dia. 9mm)
Cork Borer

(MATERIALS)
Acrylic sheet (59mm x 74mm x 3mm)..........2
Acrylic sheet (65mm x 74mm x 3mm)..........2
Acrylic sheet (65mm x 65mm x 3mm)..........2
Clear AcrylicTube (pipe) (dia. 17mm. 74 in length)..........2
Liquid Paraffin..........500g
Oil of Terpentine..........10g
Iron Filings..........1.5g
1.2 - Dichloroethane..........10cc

Rubber Stopper (Size 2)..........2
Rubber Stopper (Size 0C)..........1

6- CONSTRUCTION DETAILS

(OUTLINE)
The tube which is used to contain a magnet or electromagnet is put through the rectangular tank constructed with 3mm thick acrylic plates, as shown in Fig. A. This tank is filled with liquid paraffin, plus about 1.5g of iron filings. When a magnet is inserted into the pipe, observation can be made of the patterns of the iron filings along the lines of force in the magnetic field.

6- CONSTRUCTION DETAILS (Continued)

(DETAILS)

(1) Make a hole of the same diameter as the pipe at the centre of a piece of acrylic sheet (65mm x 65mm) as shown in Fig. 1.

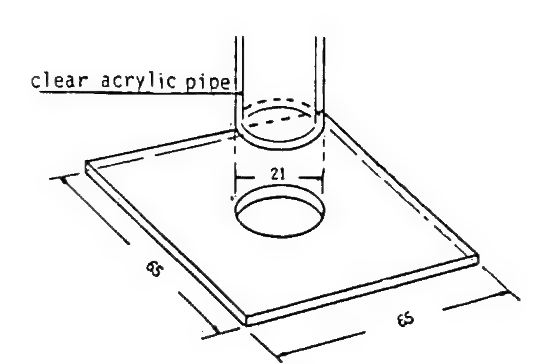


Fig. 1.

(2) Glue the tube to the board with 1.2-dichloroethane as shown in Fig. 2.

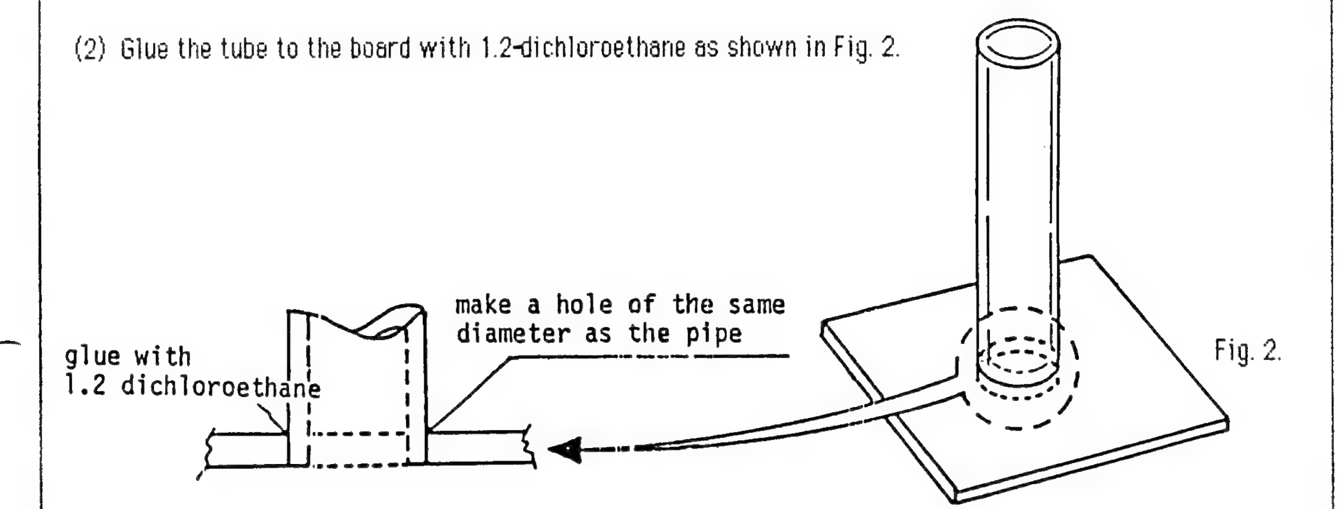


Fig. 2.

(3) Make a hole in the rubber stopper (size 2) as shown in Fig. 3.

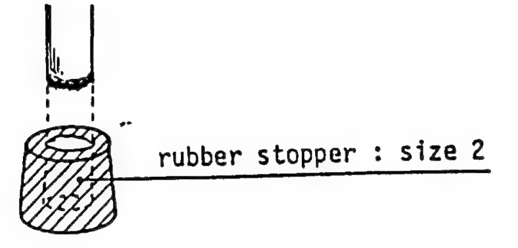


Fig. 3.

6- CONSTRUCTION DETAILS (Continued)

(4) Assemble the parts into a complete unit (Fig. 4).

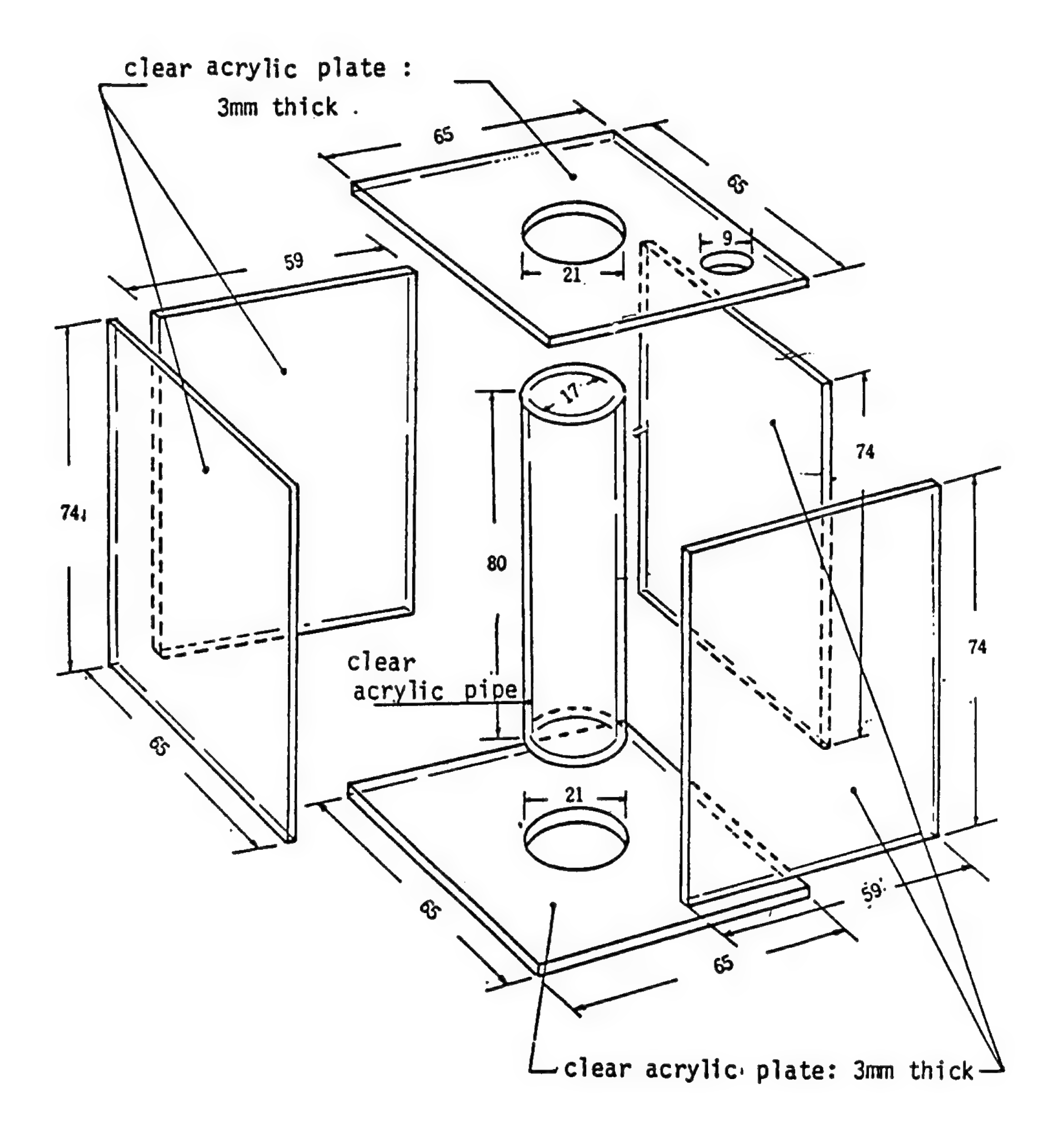


Fig. 4.

Measure and cut the acrylic plate accurately so that the liquid won't seep out.

7- METHOD OF USE

This apparatus is designed to enable one to observe the magnetic field in three dimensions by using liquid paraffin and iron fillings. Since the liquid paraffin is sealed in tightly, and the iron fillings do not stick to the magnet directly, we can use this apparatus repeatedly.

(1) Shake the unit vigorously without a magnet at the beginning of every observation.

(2) Observe the magnetic field by inserting one magnet in the tank.

(3) Observe a magnetic field by inserting two magnets in various ways in the tank.

(4) Observe a magnetic field by inserting an electromagnet instead of a permanent magnet.

1- ITEM

FORCE ON A CONDUCTOR APPARATUS.

2- PURPOSE

To investigate the relationship between current, magnetic field and force on a conductor. (Fleming's Left Hand Rule).

3- INFORMATION SUBMITTED BY

Kyoto Municipal Science Centre for Youth, Kyoto 612, Japan.

4- LINE DRAWING OF PROTOTYPE

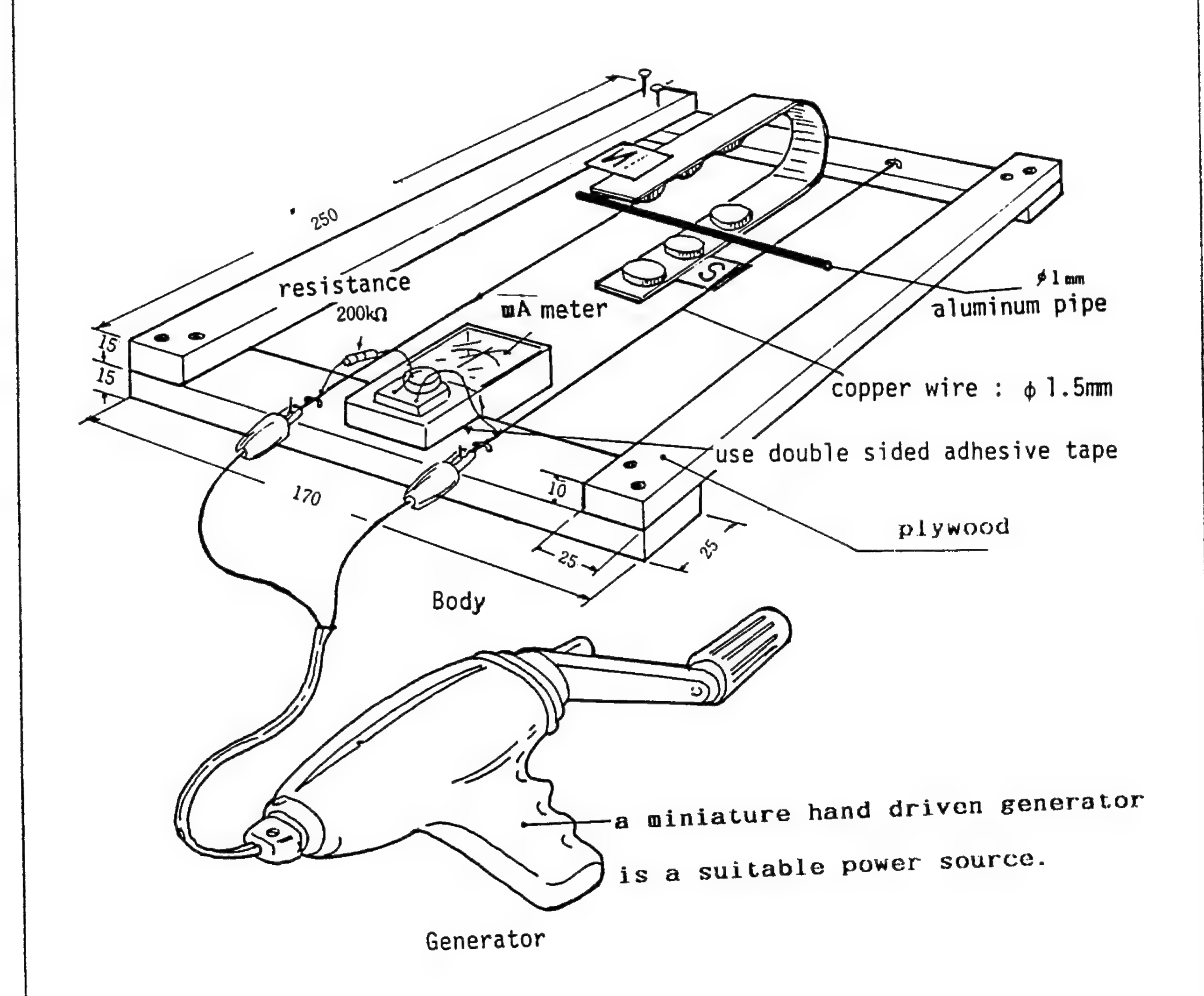


FIG. A.

5- TOOLS AND MATERIALS

(TOOLS)
Doubled-Edged saw
Planer for Wood Working
Hammer
Pliers
Tin Snips
Electric Soldering Iron

(MATERIALS)
Plywood (25mm x 500mm x 10mm)
Plywood (25mm x 340mm x 10mm)
Copper Wire (dia. 1.5 - 2mm, 50cm in length)
Aluminium Tube (dia. 1-1.5mm, 10mm in length)
Iron Plate (20mm x 170mm x 1mm)
Doubled Sided Adhesive Tape (1.5cm x 10cm)

Milli-ammeter (center zero)..1
Electrical Resistance (200kΩ,1/4W)............................1
Ferrite Magnet..6
Staple...4
Nail or Screw for Wood (2cm in length).......................4
OHP Sheet (5cm x 5cm)...1

6- CONSTRUCTION DETAILS

(OUTLINE)
Two pieces of copper wire are stretched on a wooden frame and a small aluminum tube is laid on them. One of the poles of a U-shape magnet is placed under it, as shown in Fig. A. When the circuit is complete the aluminium tube rolls back and forth. The reason for changing the back board of the ammeter with clear plastic is to clearly show, on an OHP, the direction of the current which flows through the aluminium tube.

6- CONSTRUCTION DETAILS (Continued)

(DETAILS)

(1) Frame and Rail:

Assemble the plywood strips to make a wooden frame. Stretch two copper wires in parallel, and fix them with staples as shown in Fig. 1.

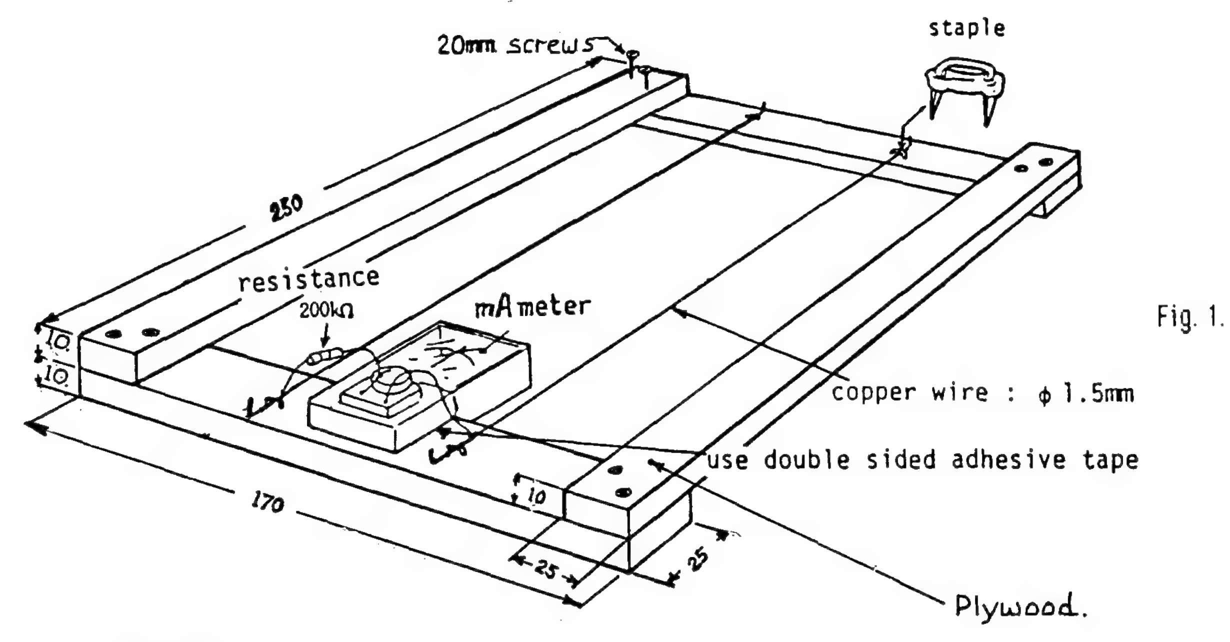
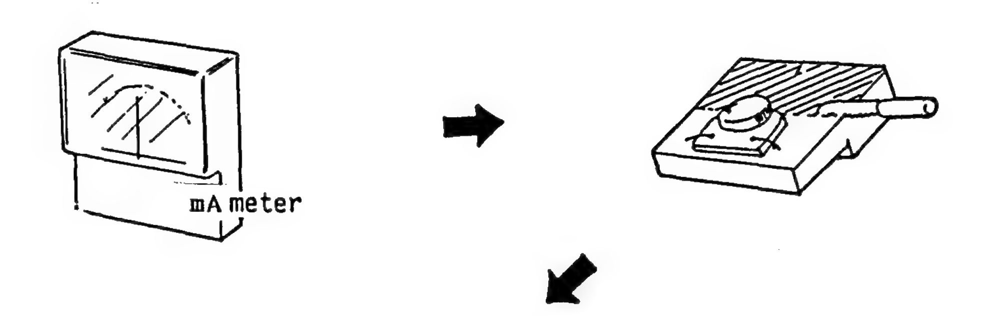


Fig. 1.

(2) Milli-Ammeter:

Cut off the opaque board from the rear side of the milli-ammeter, and change it to a clear plastic board as shown in Fig. 2.



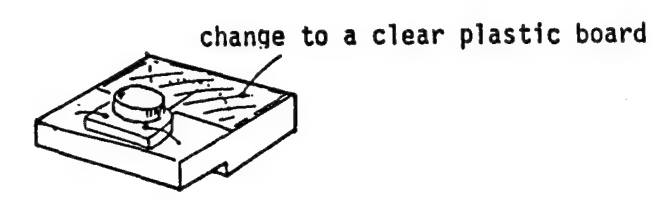


Fig. 2.

(3) Magnet:

Bend the iron plate into a U-shape, and fix to it the ferrite magnets, using double sided adhesive tape, as shown in Fig. 3. giving attention to the direction of the magnetic poles.

6- CONSTRUCTION DETAILS (Continued)

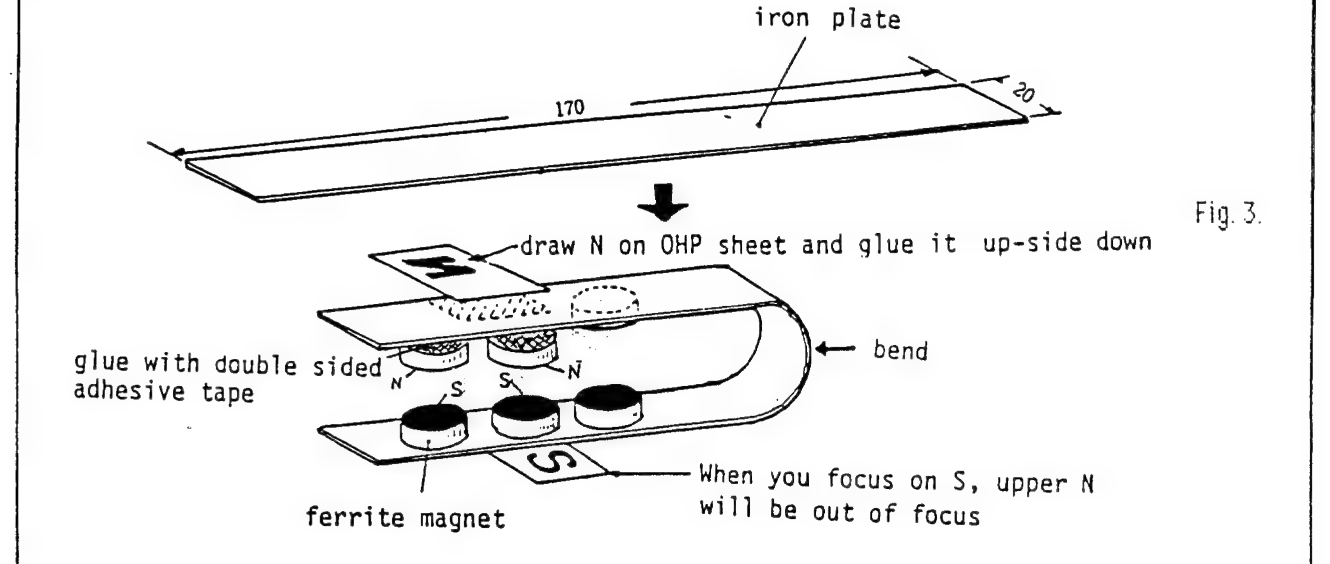


Fig. 3.

Draw the character "N" on the half part of OHP sheet, turn it upside down and glue the unwritten half of it to the upper side of the north pole.

(4) Power Supply:

Use a hand-driven generator or dry cell batteries to provide the electric current.

7- METHOD OF USE

(1) Place the wooden frame and U-shape magnet on OHP, and focus the needle of the milli-ammeter. When you focus on the letter 'S' for example, which indicates the lower arm of the U-shape magnet, the letter 'N' which is put on upper arm of it will be out of focus.
Let students understand which side of the U-shape magnet is the N or S pole.

(2) Place the small aluminium tube on the two stretched copper wires just above the ferrite magnets.

(3) Generate electricity using a hand driven generator, or by connecting the loose ends of the connecting wires from a dry cell, to the terminals, and observe the direction of the needle's deflection. Determine which of the copper wires is positive and which is negative.

(4) Examine the direction of the tube's rolling in relation to the direction of the electric current and the magnetic field.

(5) Turn the handle of the generator in reverse, and again examine the direction of the tube's rolling.

(6) Repeat the steps (1) to (5) after turning the U-shape magnet upside down.

1- ITEM

ELECTRICAL RESISTANCE APPARATUS.

2- PURPOSE

To investigate series and parallel circuits and for use as a Rheostat.

3- INFORMATION SUBMITTED BY

Kyoto Municipal Science Center for Youth, Kyoto 612, Japan.

4- LINE DRAWING OF PROTOTYPE

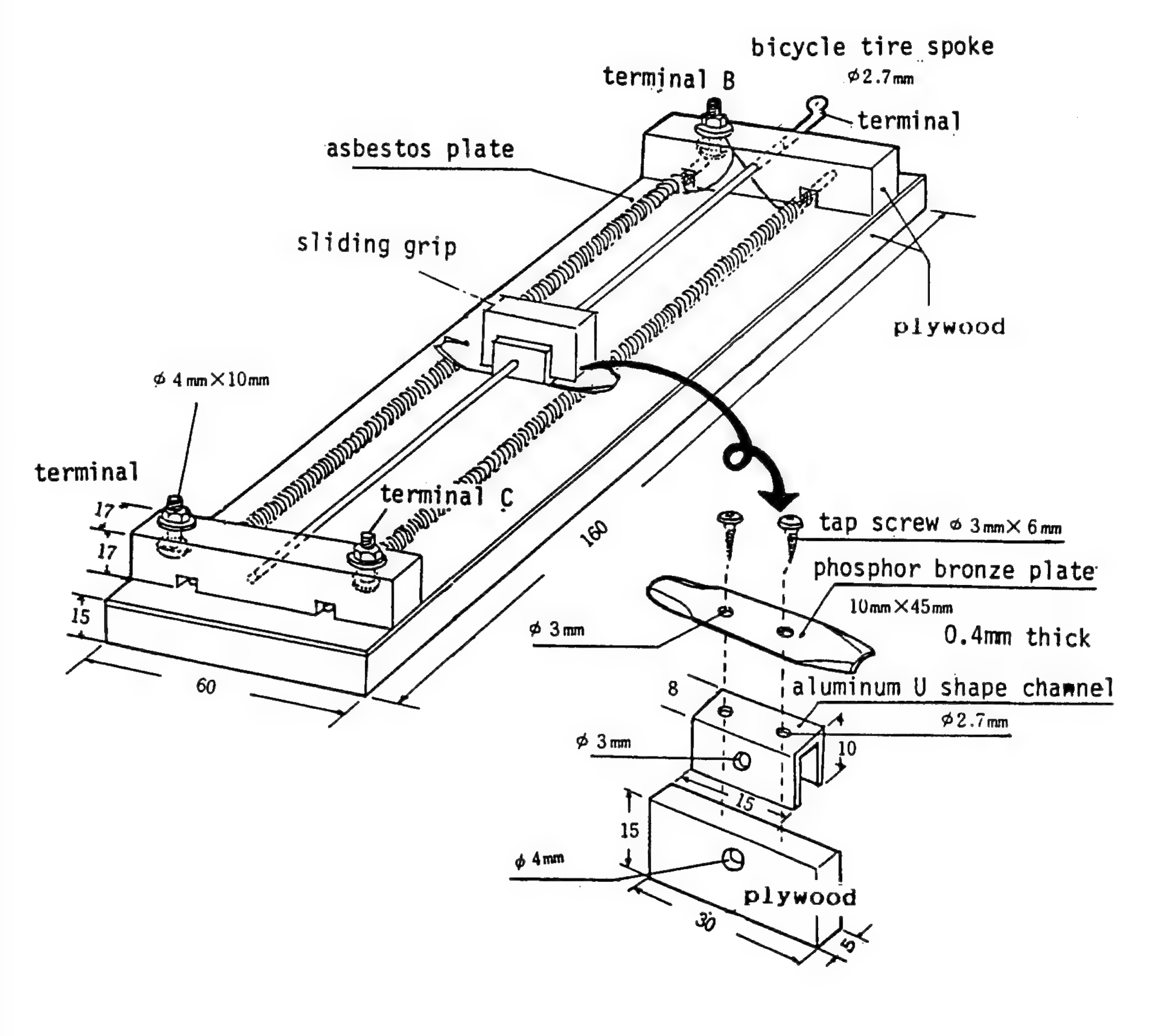


FIG. A.

5- TOOLS AND MATERIALS

(TOOLS)

Electric Hand Drill
Drill Bit (dia. 2.7mm)
Drill Bit (dia. 3.0mm)
Drill Bit (dia. 4..0mm)
Drill Bit (dia. 7.0mm)
Screw Driver
Adjustable Spanner
Diagonal Cutting Nippers
Long-nosed Pliers
Hammer
Doubled-Edged Saw

(MATERIALS)

Coiled Nichrome Wire (300W)
Heat Resistance Tube (dia. 3.2mm. 28cm in length)
U-Shape Aluminum Channel (inside width, 5mm; 1.5cm in length)
Phosphor Bronze (45mm x 10mm x 0.4mm)
Heat-resistant Sheet (160mm x 60mm x 5mm)
Plywood (160mm x 60mm x 10mm)
Plywood (60mm x 17mm x 17mm)
Plywood (30mm x 15mm x 5mm)
Bicycle Tyre-Spoke (for 26-inches bicycle)..1
Bicycle Tyre-Spoke (for motor cycle)..1
Bolt (dia. 4mm. 20mm in length)..3
Nut (dia. 4mm)..3
Washer (dia. 4mm)..3
Tap: Screw (dia. 3mm., 6mm in length)..2
Wood Screw (20mm in length)..4

6- CONSTRUCTION DETAILS

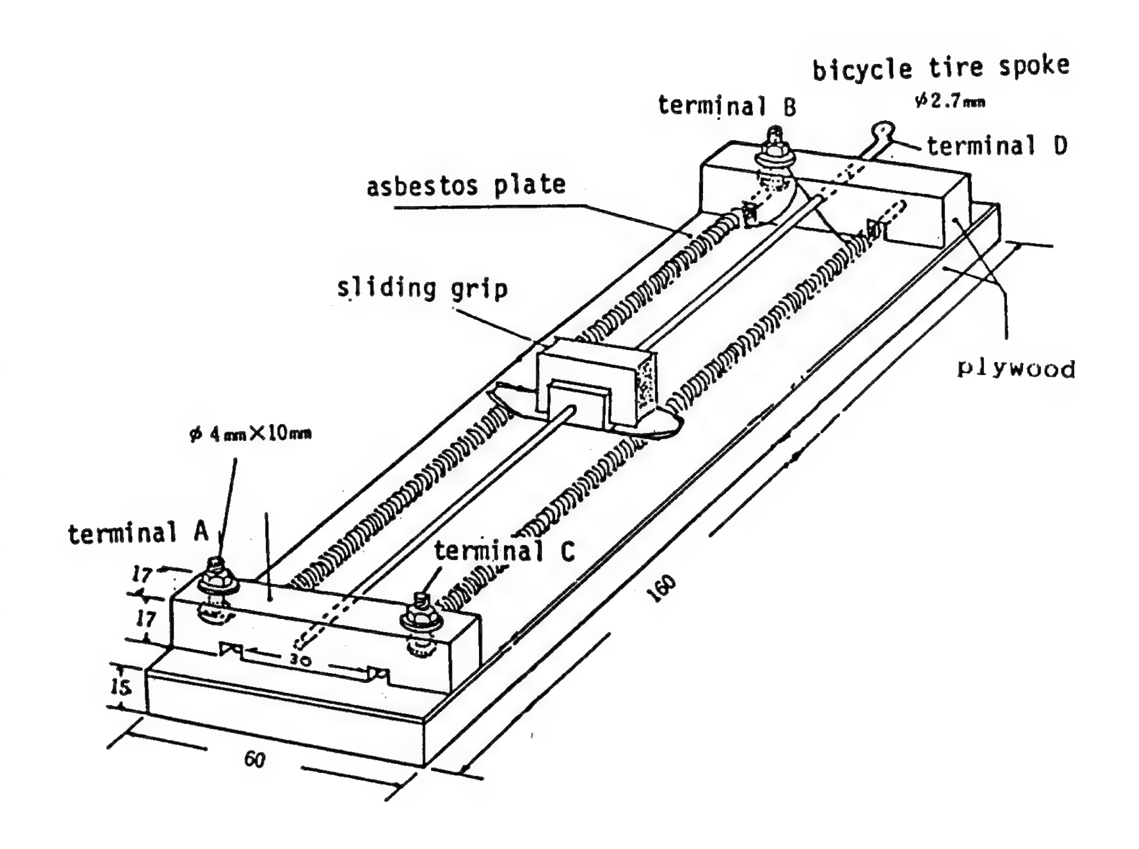
(See page 3)

6- CONSTRUCTION DETAILS (Continued)

(OUTLINE)

This equipment is composed of a resistance coil of nichrome wire, a sliding grip made in part of phosphor bronze, and a plywood table covered with heat resistance material, as shown in Fig. 1.

Fig. 1.



6- CONSTRUCTION DETAILS (Continued)

(DETAILS OF SLIDING GRIP)

The sliding grip which has a contact maker is composed of a 15mm aluminium U-shaped channel, a phosphor bronze plate, and an insulated handle. (See Fig. 2.). The insulated grip can move along the tyre-spoke guide rods. Because the contact maker completes the circuit by being pressed between the coil and a guiding spoke, the end of the guide spoke D becomes one of the electrical terminals.

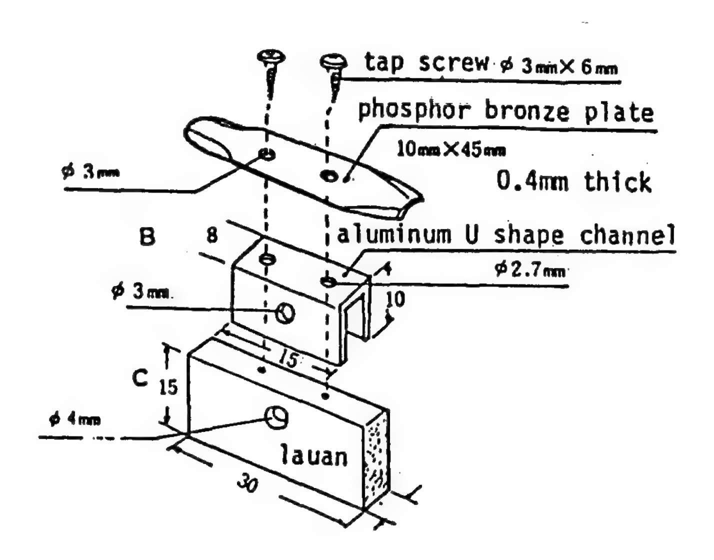


Fig. 2.

(1) Cut the phosphor bronze plate to a 10mm x 45mm strip.
(2) Fold both ends of the strip and make two holes for the screws.
(3) Cut the aluminium U-shape channel to 15mm length, and make three holes as shown in Fig. 2.
(4) Cut the plywood to a 5mm x 15mm x 30mm block, and make a hole for the spoke.
(5) Assemble parts (1)-(4) as shown in Fig. 2. and complete the sliding grip as shown in Fig. 1.

(DETAILS OF RESISTANCE COIL)

As shown in Fig. 3. stretch the middle part of a 300W nichrome coil and make two bends at both ends of the stretched part. Then the resistance value of one branch is about 15 ohms.

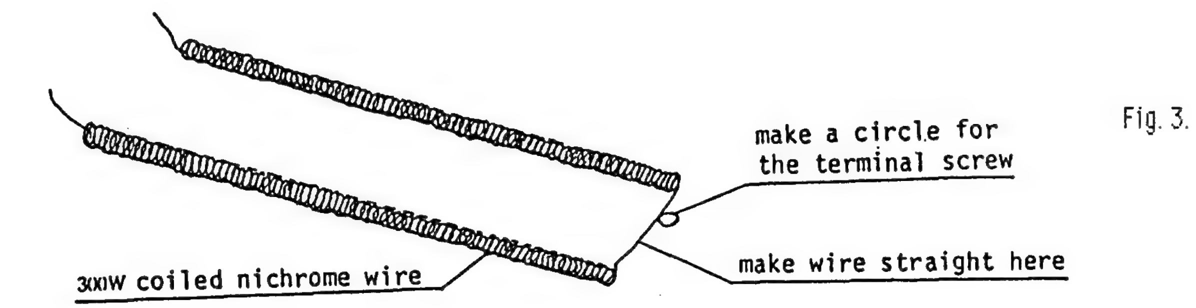


Fig. 3.

6- CONSTRUCTION DETAILS (Continued)

Each half of a bicycle tyre-spoke is covered with a heat resistant tube (500°C heatproof), being inserted into each branch of the coil. When assembled both ends of each halved spoke are firmly fixed by the holders, thus the branches don't move or stretch. (See Fig. 5).

(1) Make a straight position of 3cm long at the middle of coiled nichrome wire.
(2) Make a circle around the bolt of the terminal B, as shown in Fig. 3.
(3) Insert the bicycle tyre-spoke into the heat-resisting tube.
(4) Insert the tyre spoke covered with the heat-resistant tube into the coiled nichrome wire as shown in Fig. 4.

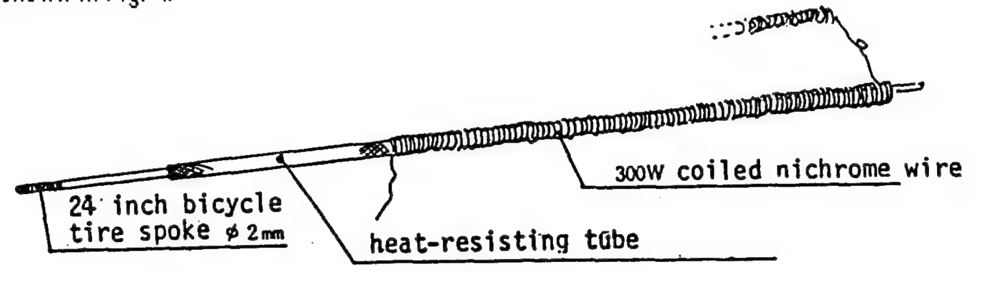


Fig. 4.

(1) Prepare the two plywood holders according to the sizes shown in Fig. 1.
(2) Prepare the base board using plywood covered with a heat-resistant material. (See Fig. 1)
(3) Assemble the apparatus as shown in Fig. 5.

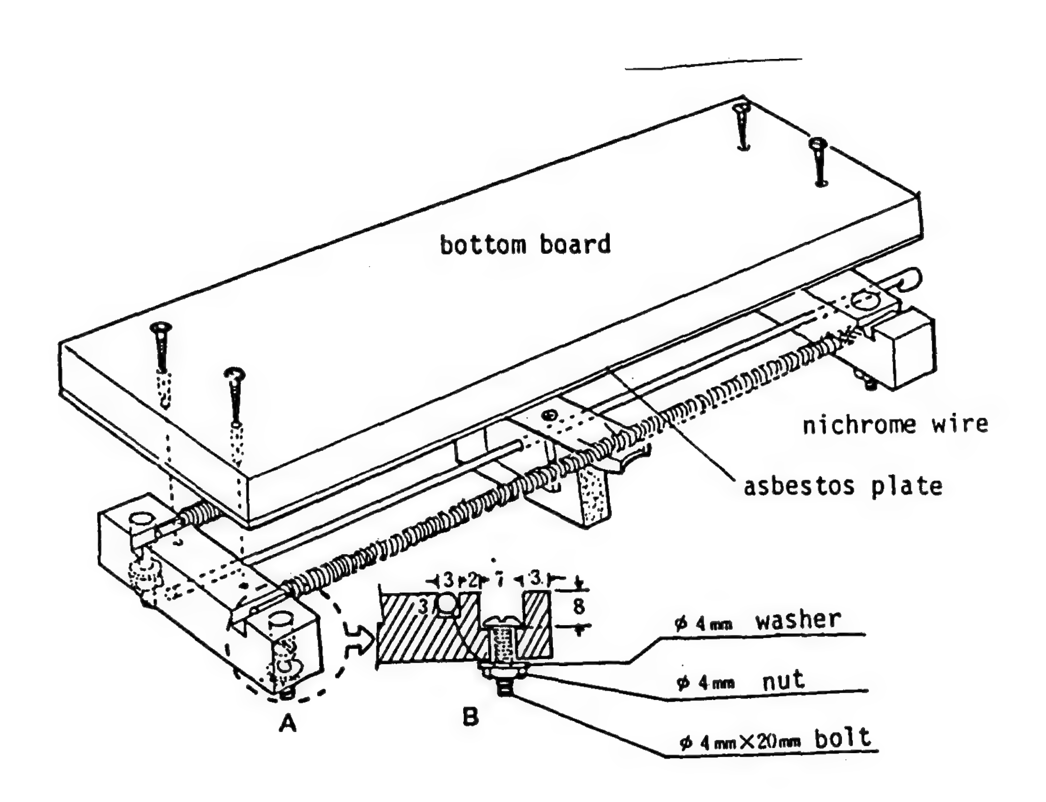


Fig. 5.

7- METHOD OF USE

(1) This equipment can be used for Ohm's law experiments and also as a rheostat.

(2) Fig. 6-a shows the way to use a single resistance wire.

(3) Fig. 6-b shows the way to make a series circuit with two resistance wires.

(4) Fig. 6-c shows the way to make a parallel circuit with two resistance wires.

(5) Fig. 6-d shows the way to use as a 0 to 30 ohm rheostat by connecting the terminals A and C.

(6) Fig. 6-e shows the way to use as a 0 to 15 ohm rheostat by connecting the terminals A and D.

(7) Fig. 6-f and g show other useful connections.

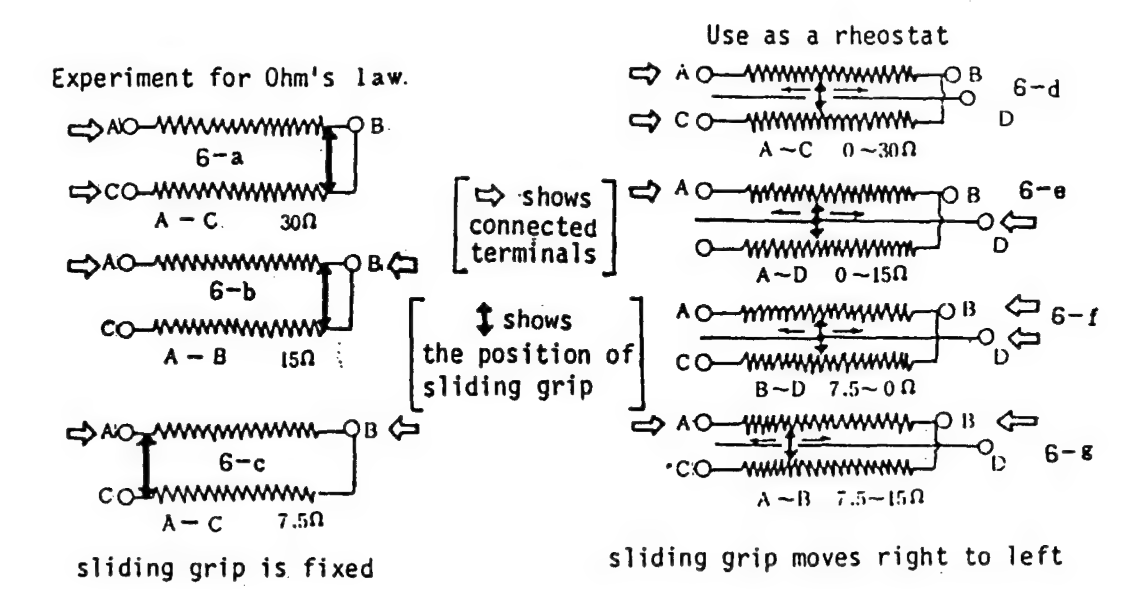


Fig. 6.

1- ITEM

PRINCIPLES OF MECHANICS APPARATUS.

2- PURPOSE

To investigate some of the principles of mechanics as applied to a windmill, water mill and seesaw.

3- INFORMATION SUBMITTED BY

Kyoto Municipal Science Center for Youth, Kyoto 612, Japan.

4- LINE DRAWING OF PROTOTYPE

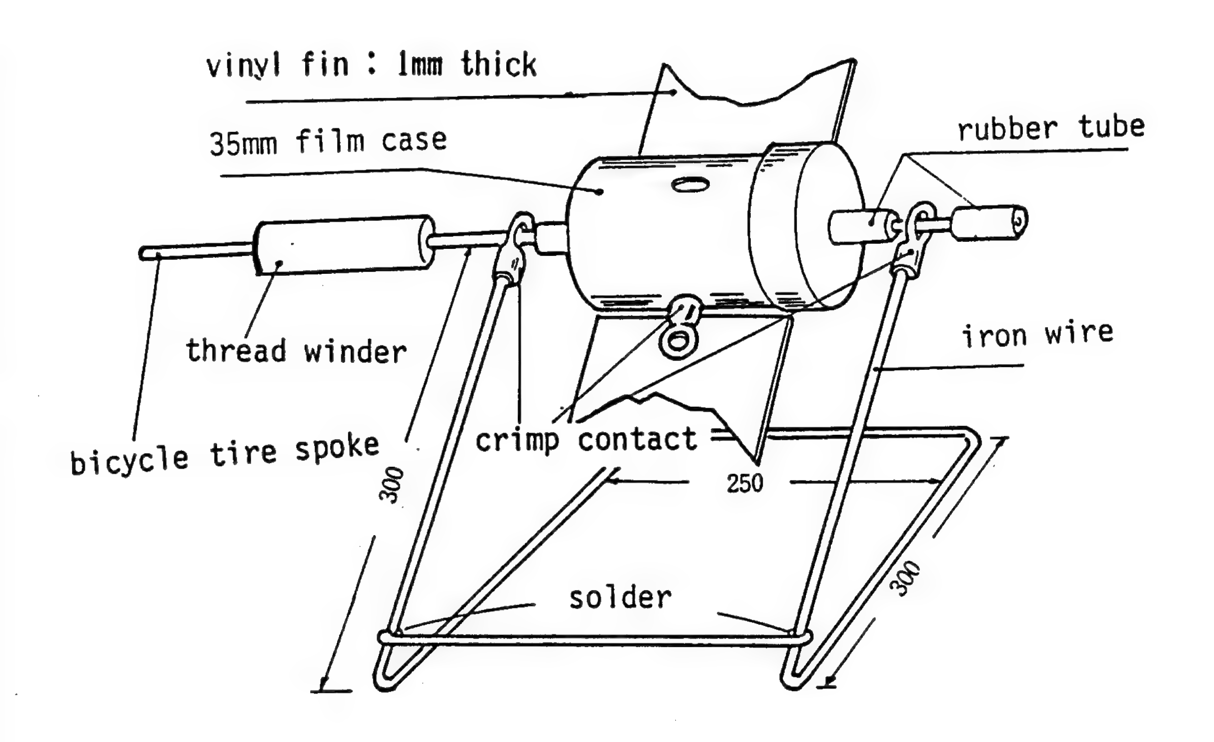


FIG. A.

5- TOOLS AND MATERIALS

(TOOLS)
Drill Bit (dia. 2mm)
Drill Bit (dia. 5mm)
Pliers
Eyelet Punch
Cutter for Plastics
Cork Borer
Electric Soldering Iron
Cable Joint Pliers

(MATERIALS)
Galvanized Iron Wire (No. 12, 60cm in length)

Cake Box (100mm x 350mm).................... 1
Vinyl Board (40mm x 140mm).................... 4
Vinyl Board (40mm x 70mm).................... 1
Eyelet.................... 8
Solderless Terminal.................... 10
Empty Film Case (35mm).................... 1
Rubber Stopper (Size 9).................... 1
Bicycle Tyre Spoke.................... 1
Bicycle Rim Screw.................... 2
Rubber Tube.................... 2

6- CONSTRUCTION DETAILS

(OUTLINE)
The fins, made of vinyl sheet, are attached to the plastic 35mm photographic film case as shown in Fig. 1. A bicycle tyre spoke acts as an axle, and it is supported by an appropriate frame made of pieces of wire.

6- CONSTRUCTION DETAILS (Continued)

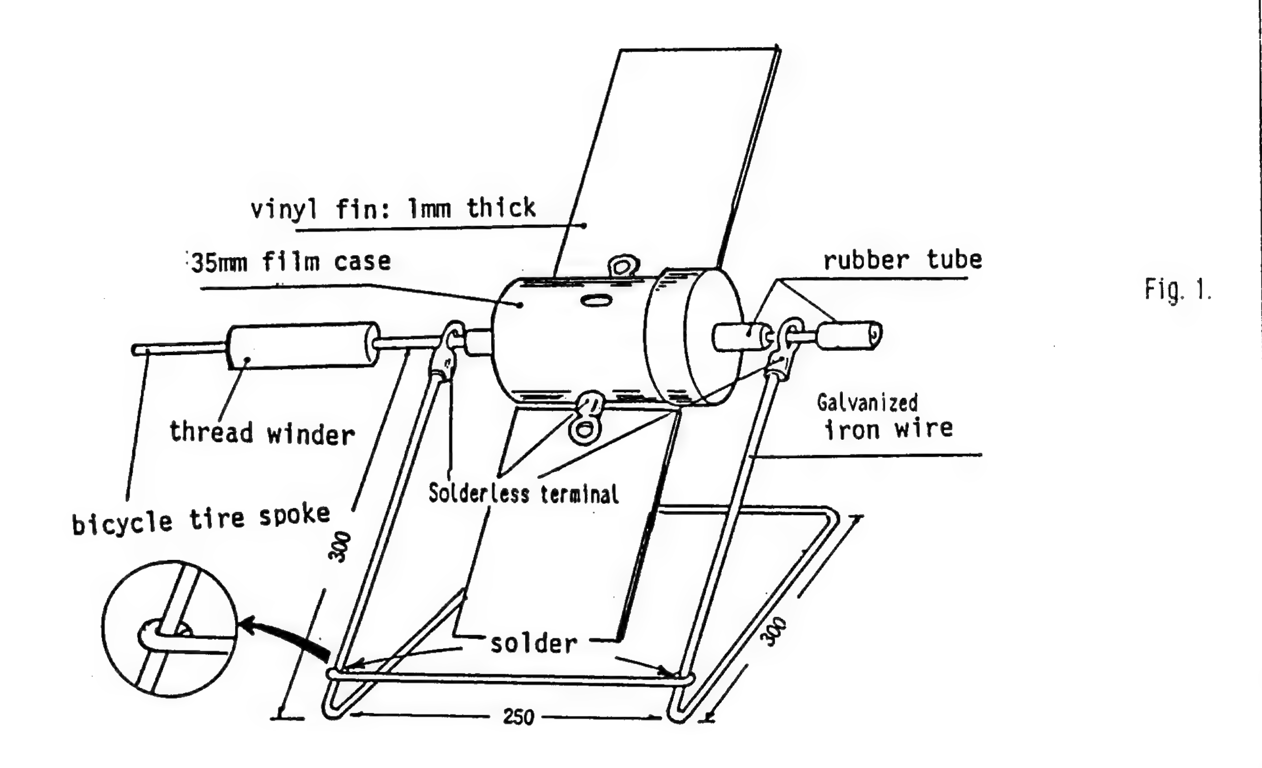


Fig. 1.

(1) DETAILS OF FINS

(1) Cut vinyl board to 40 x 140mm sheet.

(2) Make a hole of dia. 5mm at the edge of the board.

(3) Fix a terminal to the board with eyelet (see Fig. 2.).

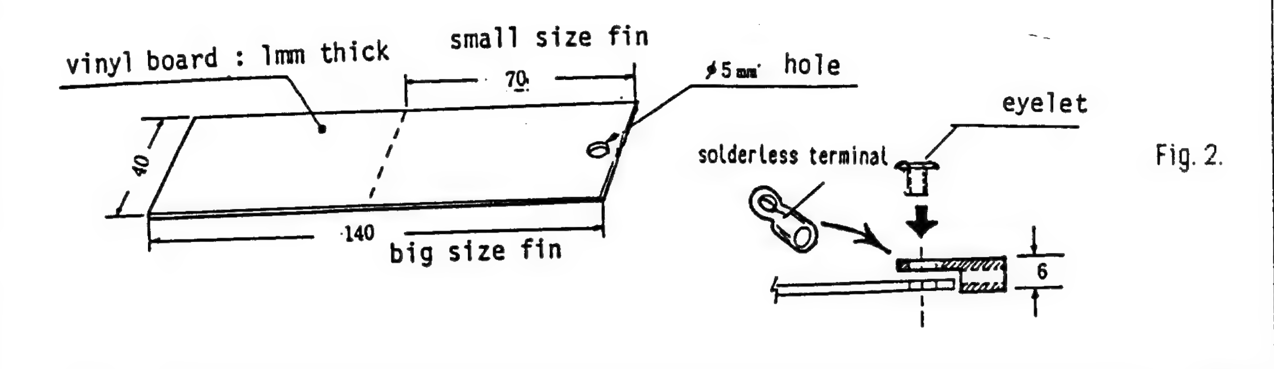


Fig. 2.

(2) DETAILS OF AXLE

(a) Make a hole using a drill bit, in the rubber stopper for the shaft. (See Fig. 3.).

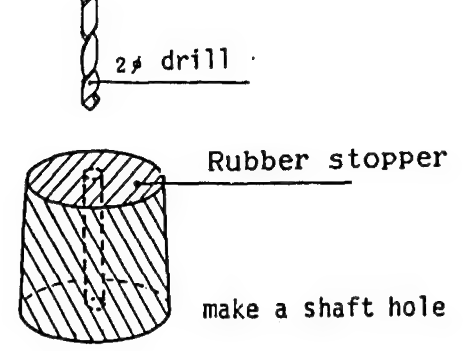


Fig. 3.

(b) Drill out a centre core for use as a thread winder. (See Fig. 4).

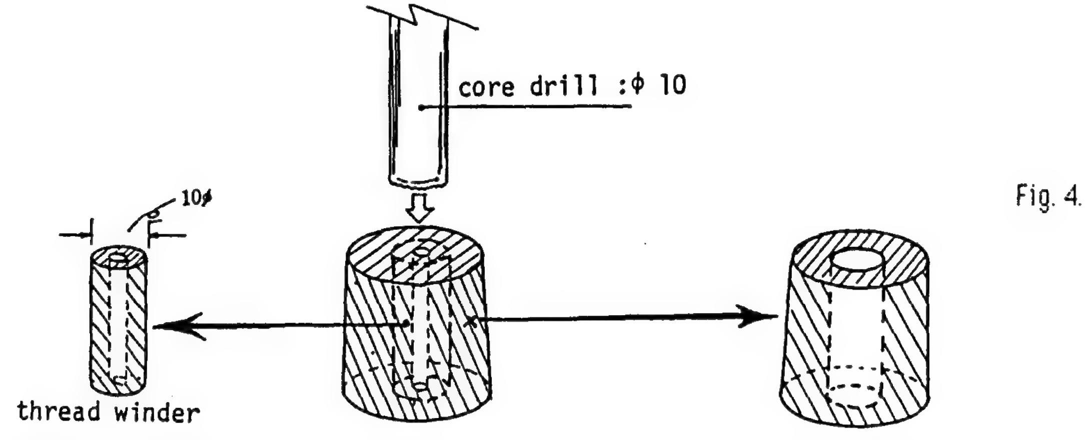
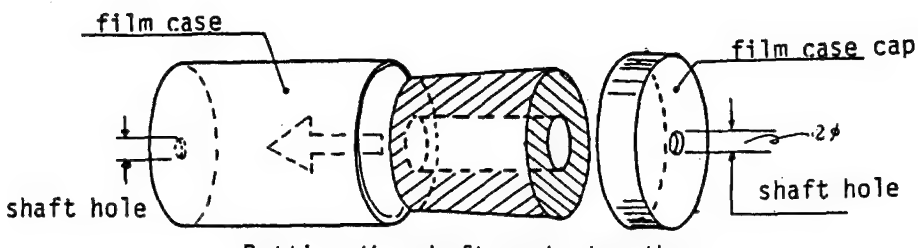


Fig. 4.

(c) Make holes in film case, and its cap, for a shaft.
(d) Insert the rubber stopper in the film case.
(e) Put the shaft parts together. (See Fig. 5)



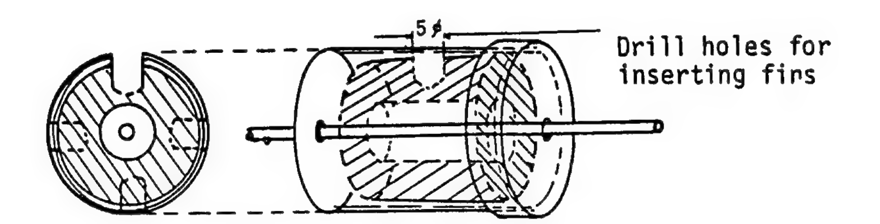
Putting the shaft parts together

Fig. 5.

6- CONSTRUCTION DETAILS (Continued)

(e) Make holes by drill bit for inserting fins. (See Fig. 6).

Fig. 6.



(g) Assemble the parts into a complete unit and cut the unnecessary bicycle tyre spoke. (See Fig. 7).

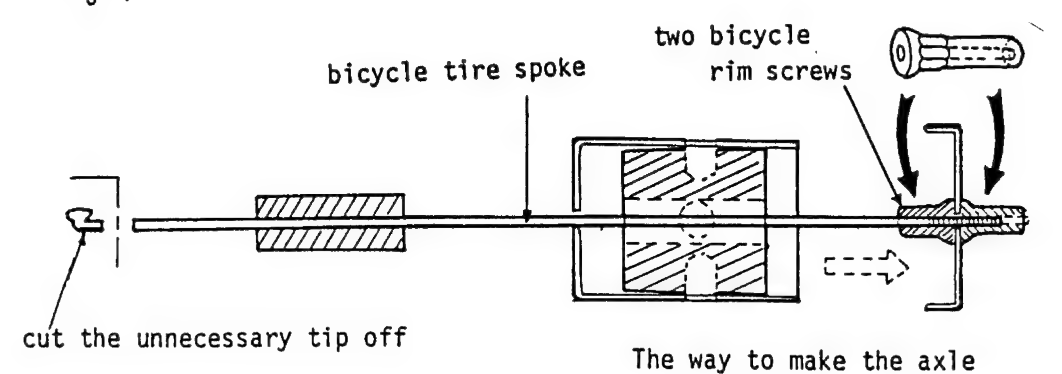


Fig. 7.

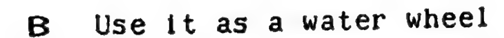
(3) DETAILS OF FRAME

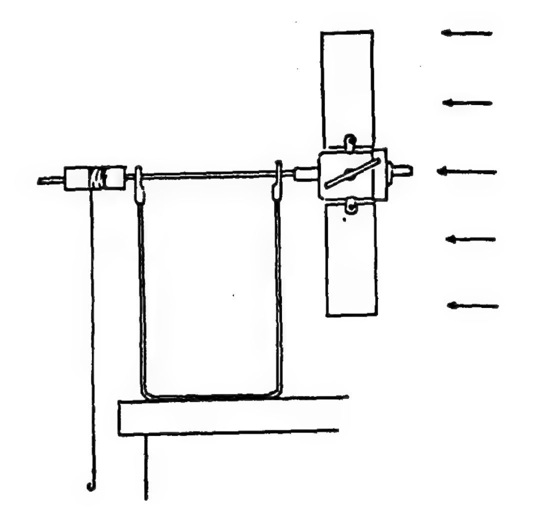
Using a 60cm length of 12 gauge galvanised iron wire construct a frame as shown in Fig. 1. The cross-member should be soldered for added rigidity. The solderless electrical terminals should be tightly crimped onto the ends of the frame.

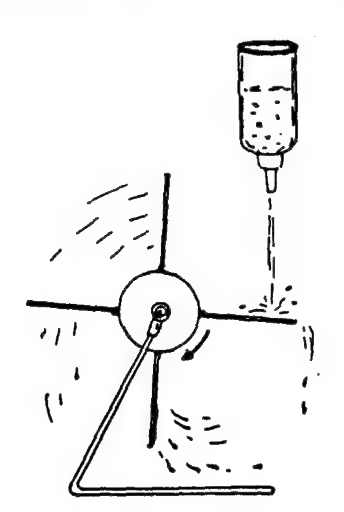
7- METHOD OF USE

This equipment is designed to be used as a windmill, a water wheel, or a seesaw as shown in the diagram below, with the intention of helping students understand the common principles behind the various systems' movements through seeing it demonstrated and used many times in various ways.

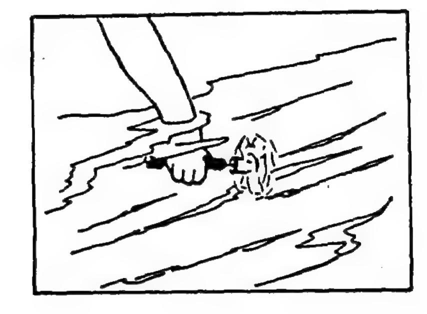
A Use it as a windmill



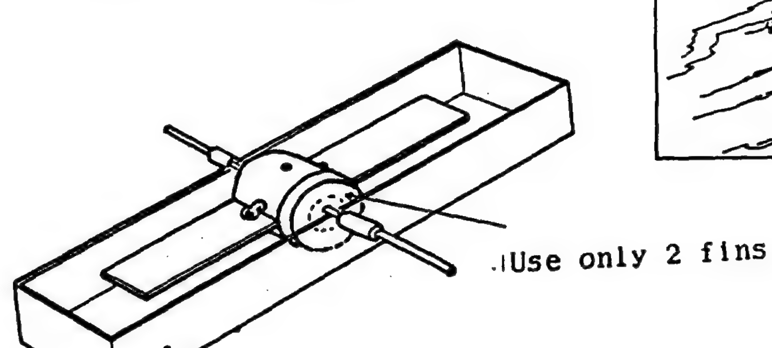




C Use it in flowing water



D Use it as a seesaw



1- ITEM

COMPOSITION OF FORCES APPARATUS.

2- PURPOSE

To investigate the composition, direction, and equilibrium of forces.

3- INFORMATION SUBMITTED BY

Kyoto Municipal Science Center for Youth, Kyoto 612, Japan.

4- LINE DRAWING OF PROTOTYPE

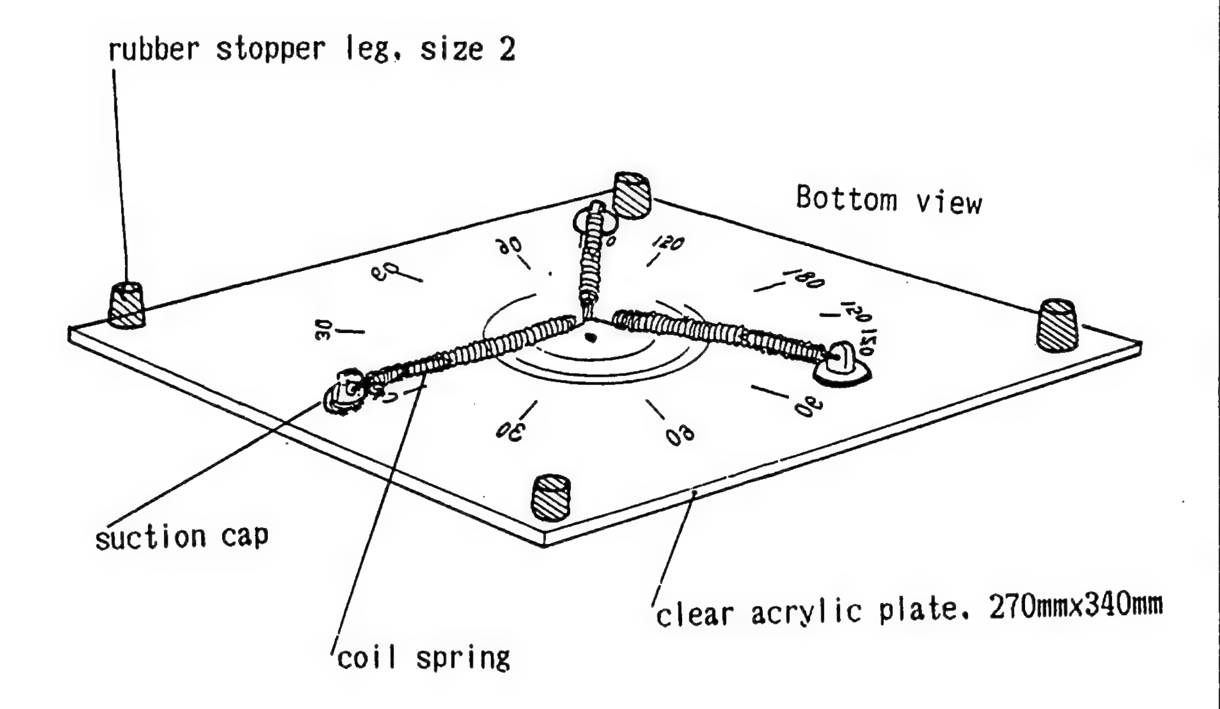


FIG. A.

5- TOOLS AND MATERIALS

(TOOLS)
Cutter for plastics
Pencil sharpener
Diagonal Cutting Nippers
Screw Driver

(MATERIALS)
Wooden Rod (dia. 8mm. 18cm in length)
Metal Tube (pipe) (aluminium, dia. 1mm, 7mm in length)
Strong thread (1m in length)

Acrylic sheet (270mm x 340mm x 3mm)..1
Coil Spring (dia. 10mm, 50mm in length, expansion 4mm/10g)...............1
Suction Cup (dia. 20mm)..3
Rubber Stopper (Size 2)..4

6- CONSTRUCTION DETAILS

(OUTLINE)
This instrument is composed of a metered board on which is drawn degrees of 0° - 180° and concentric circles at equal intervals. Three coil springs have suction caps at one end and a holding sleeve at the other end as shown in Fig. 1.

6- CONSTRUCTION DETAILS (Continued)

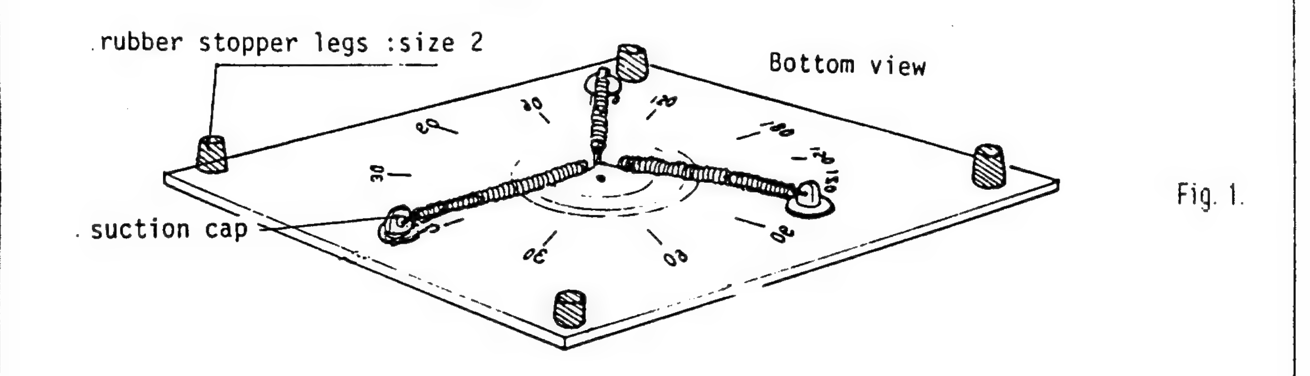


Fig. 1.

Inside the coil springs are wooden rods which can move back and forth freely. One end of each rod is likewise tied with the spring to the suction cap.

The metered board is made of transparent acrylic resin so that the teacher can show this experiment on an overhead projector. This apparatus can also be used by students.

(1) DETAILS OF METERED BOARD

(1) Cut the Acrylic Board to 270mm x 340mm rectangle
(2) Draw concentric circles at 8mm intervals.
(3) Mark 180° degrees with an indelible marker. (See Fig 2)

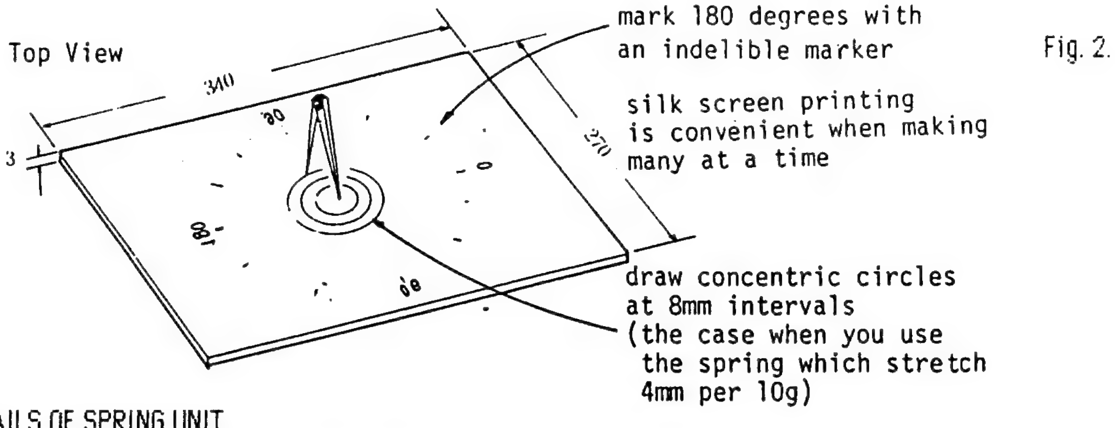


Fig. 2.

(2) DETAILS OF SPRING UNIT

i. Use a coil spring which stretches 4mm per 10g.
ii. Cut the wooden rod, dia. 8mm, 55mm in length. (See A in Fig. 3).
iii. Sharpen one end of the wooden rod with a pencil sharpener (See B in Fig. 3).
iv. Uncoil one end and stretch it out straight 20mm. (See C in Fig. 3)
v. Trim other end for tie rod end and suction cap. (See D in Fig. 3).
vi. Make a hole and run a thread through. Pull the other end of thread through into the coil spring. (See E in Fig. 3).
vii. Bend the spring wire uncoiled along the tip of the rod. (See F in Fig. 3).
viii. Tie the spring and the rod together to the suction cap. (See G in Fig. 3).
ix. Make three coil spring units in the same way.
x. Assemble the three coil spring units. (See Fig. 4).

6- CONSTRUCTION DETAILS (Continued)

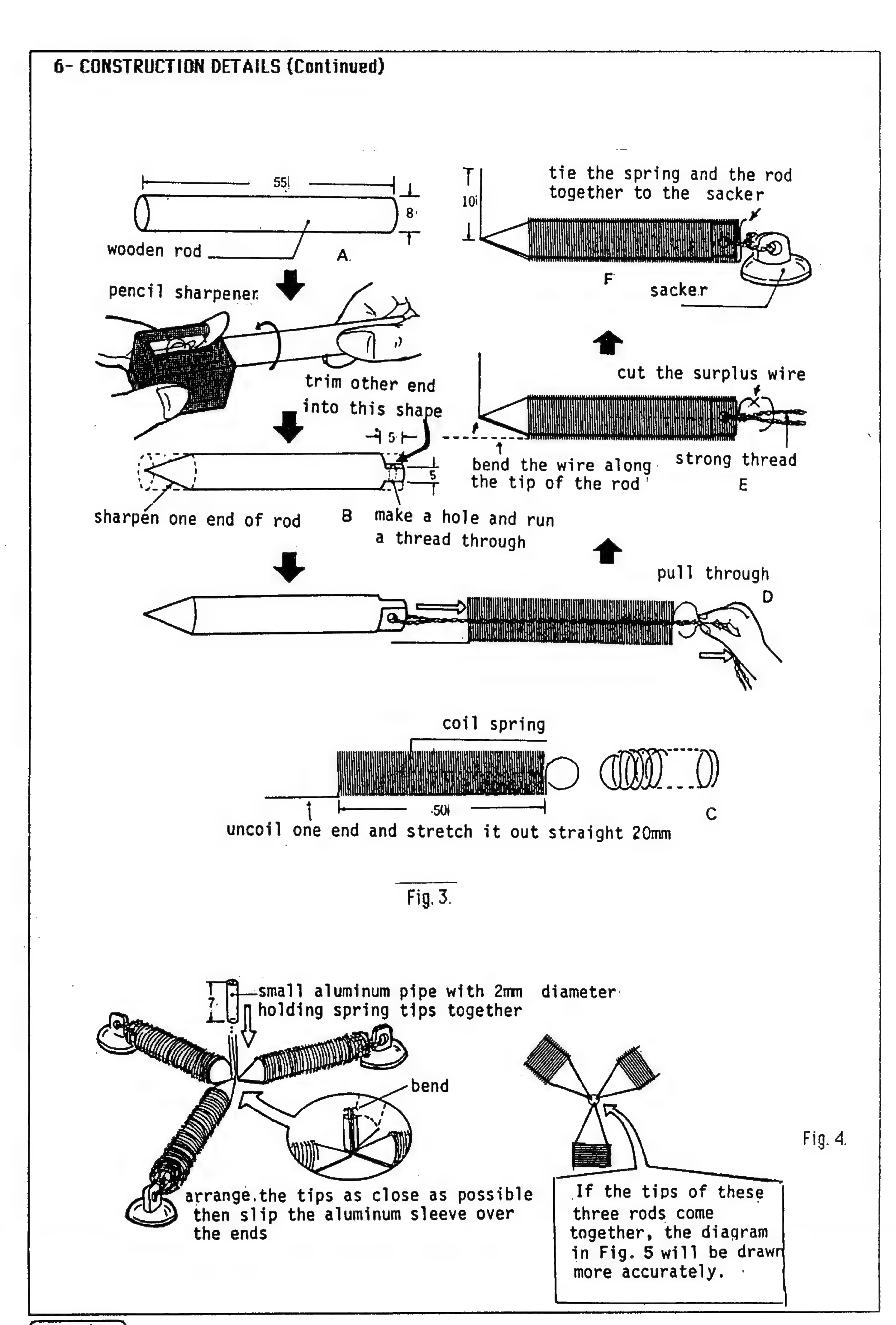


Fig. 3.

Fig. 4.

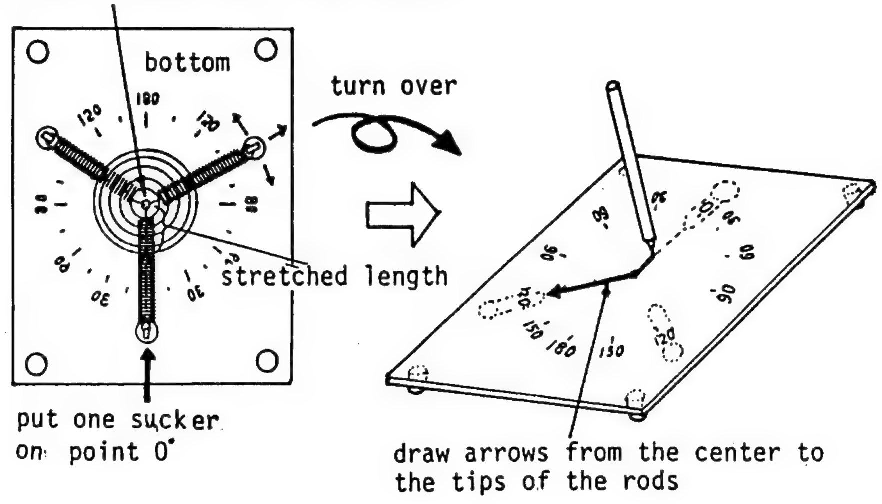
7- METHOD OF USE

First, place the suction cups at the point where the ends of the pointed rods come closest to their linking point and the springs are free from tension.

When the suction cups are moved away from the center of the board, the elongation of the springs will be approximately equal to the distance between the linking point and the tips of each rod.

Draw arrows from the board's center to the pointed tips of each rod, then show the direction and distance of the three balanced forces.

Moving the positions of two of the three suction caps and pointing out the same spring lengths and distances, will make a very graphic demonstration for the students.



1- ITEM

MICRO-ORGANISM MEASURING SCALES.

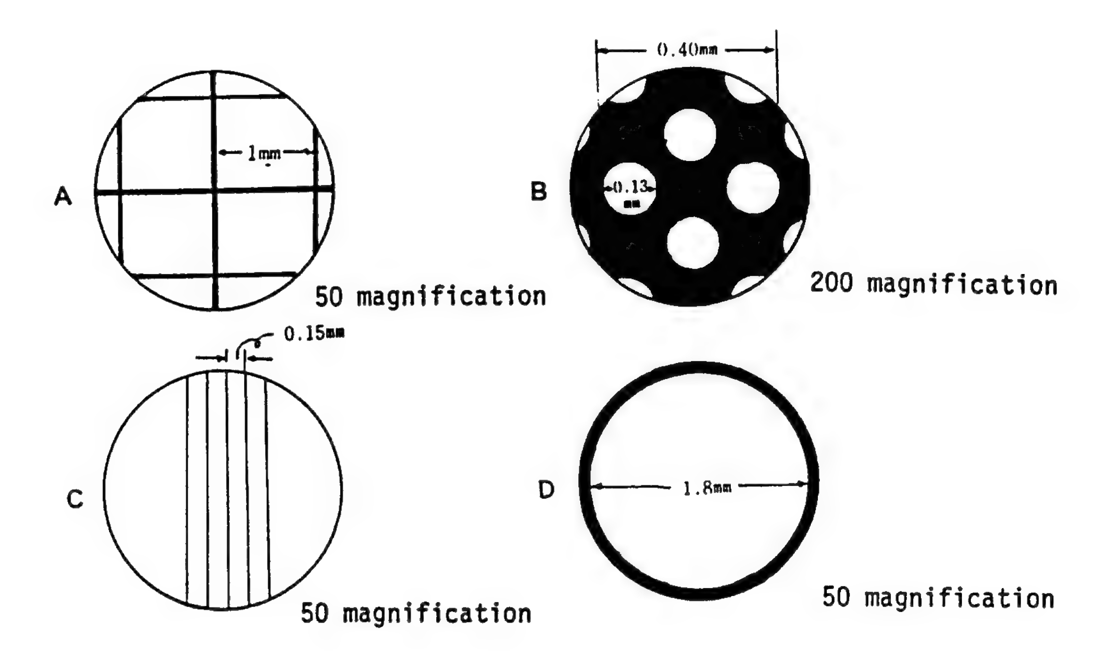
2- PURPOSE

To determine the number and size of micro-organisms when viewed under a microscope.

3- INFORMATION SUBMITTED BY

Kyoto Municipal Science Center for Youth, Kyoto 612, Japan.

4- LINE DRAWING OF PROTOTYPE



A 1mm squares ruled on clear plastics sheet

B holes of copper mesh for electron microscopy

C scores made by piled razor blades on clear plastics sheet

D holes made by a computor tape puncher

FIG. A.

5- TOOLS AND MATERIALS

(TOOLS)
Razor Blades
Scissors
Cutter for Plastics
Electric Hand Drill
Drill Bit (dia. 10mm)
Punch for Computer Tape.

(MATERIALS)
TP Sheet (poly trimethyl-pentene: 1mm sections printed on)
Rubber Band
Copper Mesh (for electron microscopy. 1/8 in. no. 150)
Label Tape
Vinyl Sheet (1mm thick)
Instant Adhesive (cyanoacrylate based)
Glass Slide.

6- CONSTRUCTION DETAILS

1. TRANSPARENT SHEET RULED IN 1MM SQUARES

Cut out the vinyl sheet of 25 x 70mm (same size as a glass slide), and make round window of dia. 10mm in the middle part of it.

Cut out a square of 15 x 15mm from TP sheet ruled into 1mm squares. Glue it to the under side of the plate around the window. (See Fig. 1.)

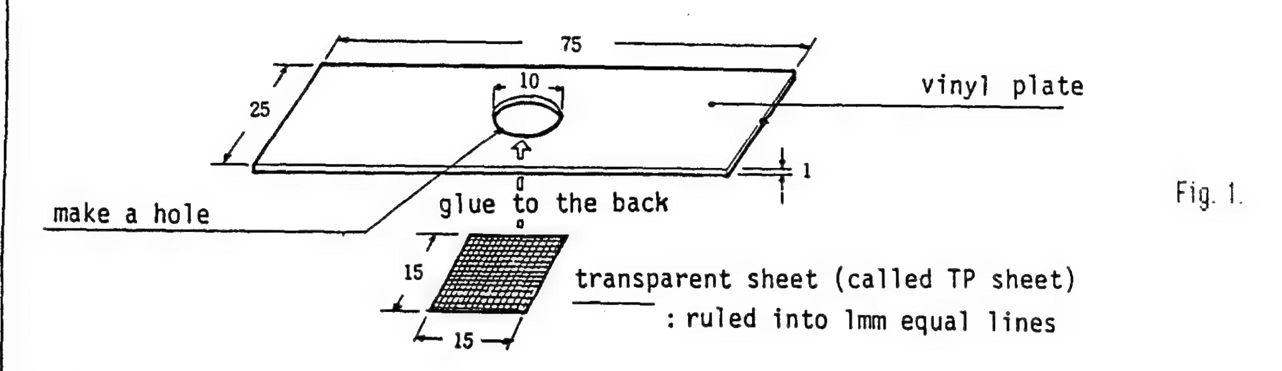


Fig. 1.

Alternatively:
The square of 15mm may be glued to a glass slide as shown in Fig. 2. Take care of excess adhesive that will depress the resolving power of the microscope and deform the image.

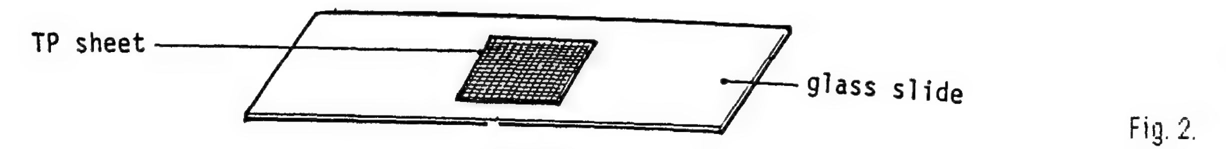


Fig. 2.

(2) Electron Microscope Grids.
Glue the copper mesh on a glass slide as shown in Fig. 3. Take care not to use too much adhesive.

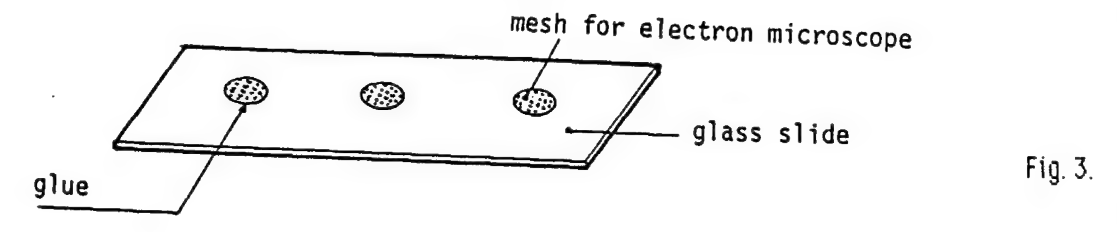


Fig. 3.

3) Scored Lines.
Bundle razor blades with a rubber band as shown in Fig. 4. Put a TP sheet around any cylinder, and make scores by putting the blades on the sheet and rotating the cylinder slowly. The rubber band is convenient to equalize the forces applied to the edges of the blades, rather than adhesives that stick the blades together.

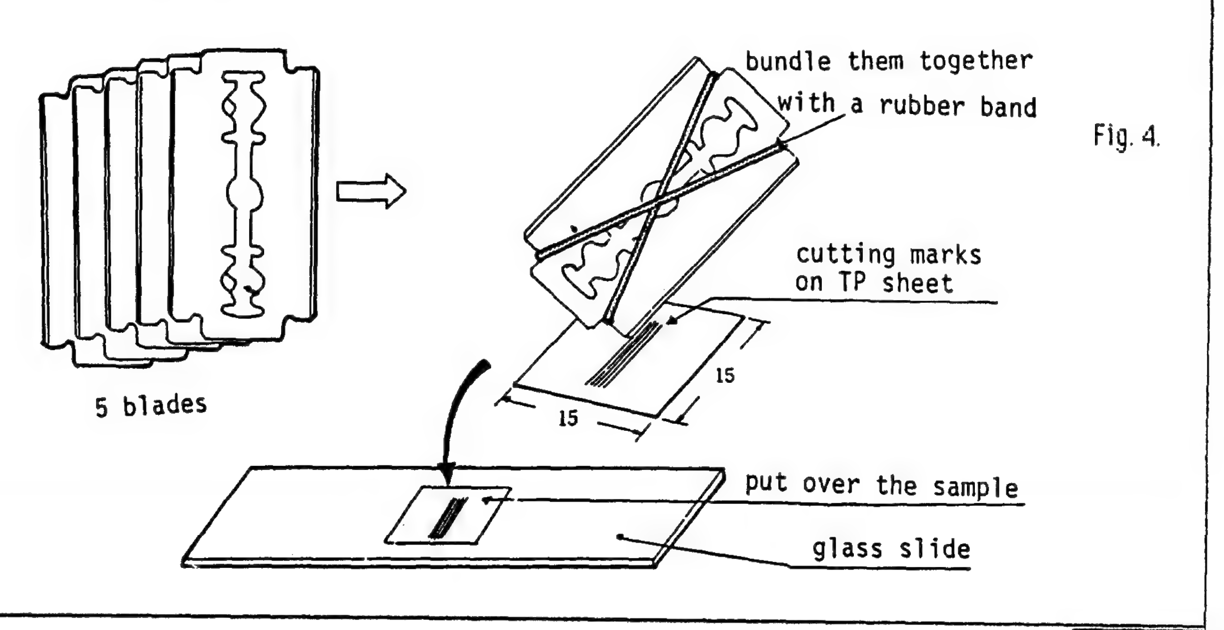


Fig. 4.

6- CONSTRUCTION DETAILS (Continued)

(4) Affix label tape on TP sheet, and make holes with a tape puncher. (See Fig. 5). The sheet should be thin enough so that it can be applied to the punch even if its thickness is increased by the tape (about 0.2mm).
Cut off a suitable part of the tape to a square of 15 x 15mm.

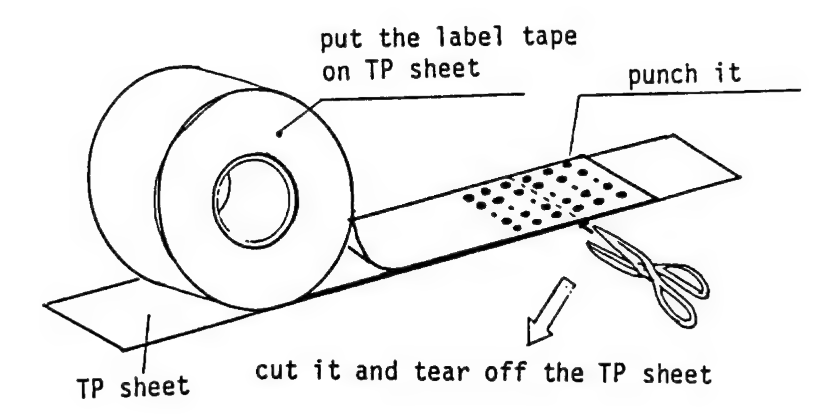
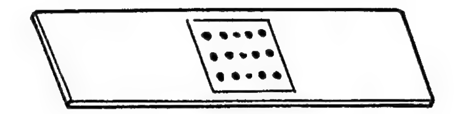


Fig. 5.

Strip off the tape from the TP sheet, and affix it on a glass slide as shown below.



7- METHOD OF USE

(a) 1mm squares:

The field of microscope of x50 magnification covers four squares (see Fig. 6), and that of x100 magnification one square. The squares glued to the window of a vinyl slide of 1mm in thickness will be conveniently used to count aquatic microorganisms in 1 mm^3 of the sample water. The counting will become easier when the organisms are fixed and sunk to the bottom by adding 0.05% nickel sulfate to the water. The squares glued to a glass slide will be suitable to measure the size of microorganisms.

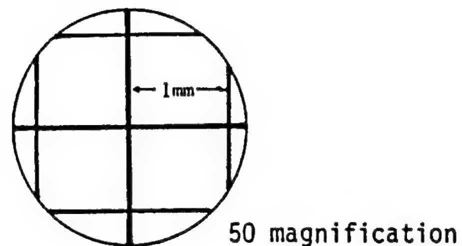


Fig. 6.

(b) Holes of copper mesh:

The diameter of 0.13mm of the holes will be used as a suitable scale for pollens. The diameter of 0.40mm of the circle enveloping adjacent four holes (Fig. 7) will be used as a scale for larger objects.

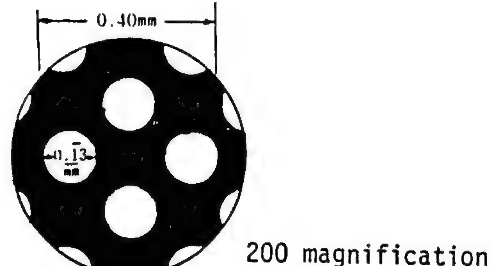


Fig. 7.

(c) Razor blade scores:

Cut the scored TP sheet to a 15 x15mm square. It will be used in the same way as a glass cover slip. (Fig. 8.)

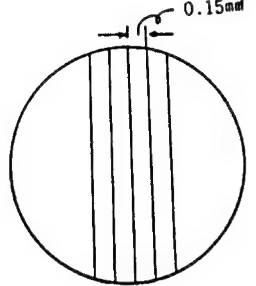


Fig. 8.

(d) Holes made by a tape punch:

Drop the sample water on the glass slide on which the punched tape is affixed; Allocate the water to each hole with a needle, and wipe out the excess water with tissue paper. (Fig. 9). Since the label tape is about 0.2mm thick, the micro-organisms are caged within a shallow pool and easily observed under a micro-scope without any chemical to retard their motion, even if they move briskly.

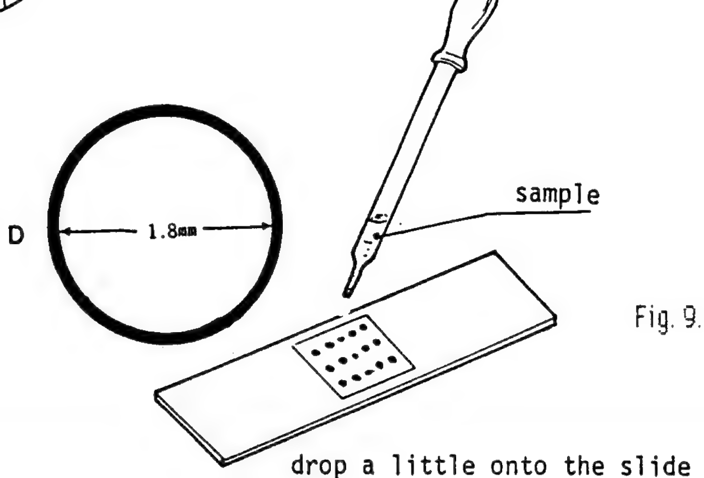


Fig. 9.

1- ITEM

SMOKE CELL.

2- PURPOSE

To observe the Brownian motion of smoke particles

3- INFORMATION SUBMITTED BY

Kyoto Municipal Science Center for Youth, Kyoto 612, Japan.

4- LINE DRAWING OF PROTOTYPE

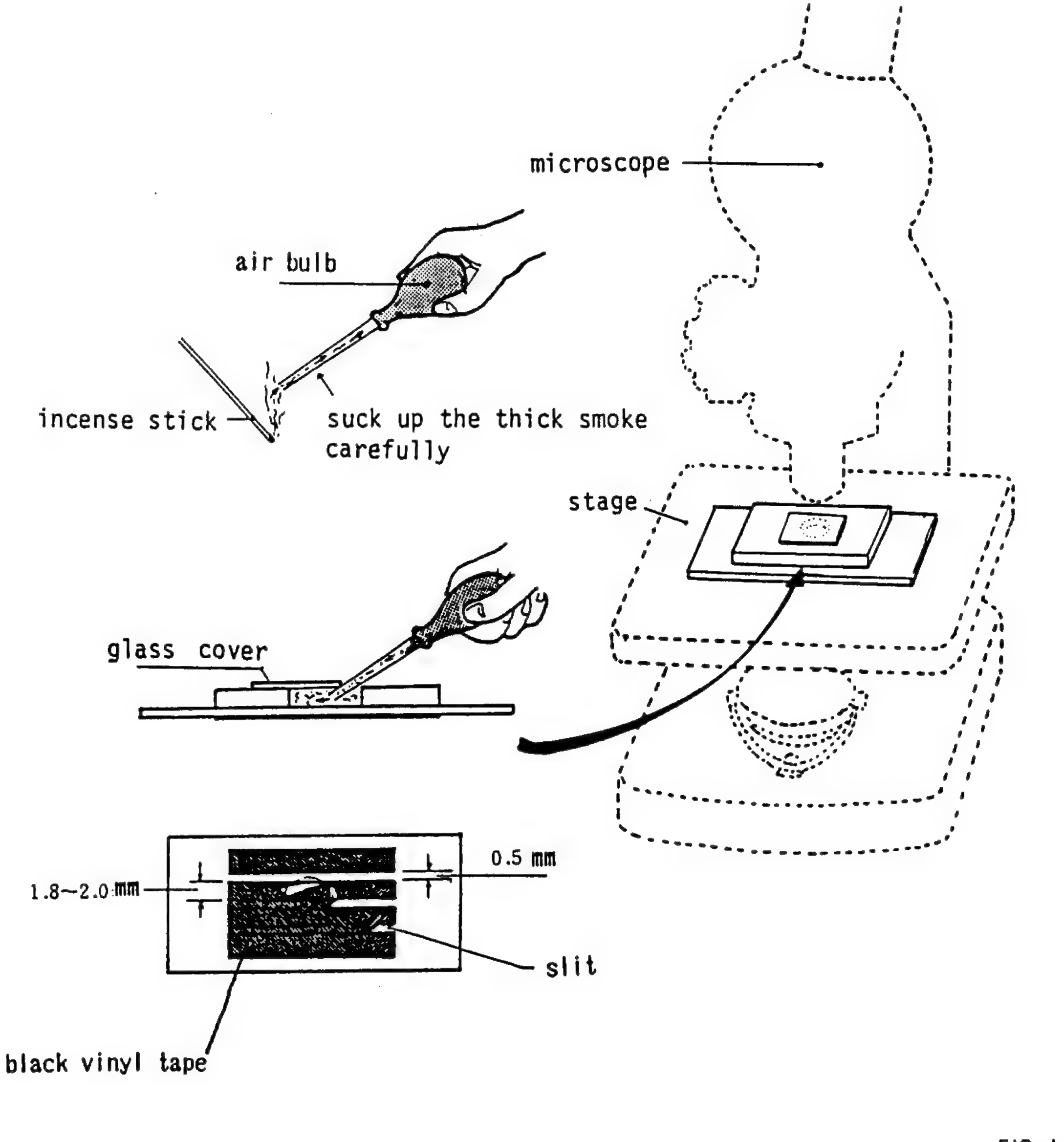


FIG. A.

5- TOOLS AND MATERIALS

(TOOLS)
Electric Hand Drill
Drill Bit (dia. 5mm - 7mm)
Cutter for Acrylic Board
Razor Blade
Ruler
Tweezers

(MATERIALS)
White Acrylic Sheet (3mm thick)
Vinyl Tube (dia. 9mm)
Double Sided Adhesive Tape (20mm width)
Electric Insulating Tape (Black)

Microscope Slide...1
Cover Glass..1
Plastic Lens (dia. 25mm. 70mm focal length).........2
Clothespin..1

6- CONSTRUCTION DETAILS

PROCEDURES TO MAKE A SMOKE CELL
Cut a white acrylic plate of 3mm in thickness to a 50mm x 20mm rectangle and make a hole of 7mm diameter, as shown in Fig. 1.
Alternatively pile up several card boards to the same dimension and paste them together.

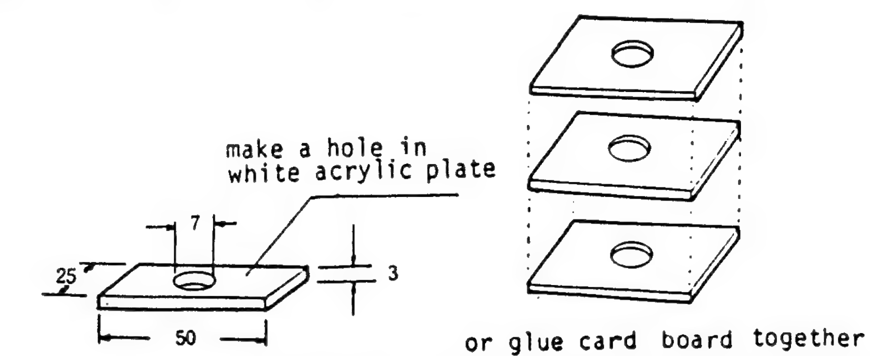


Fig. 1.

6- CONSTRUCTION DETAILS (Continued)

Stick a plate to a glass slide with double sided adhesive tape. (Fig. 2).

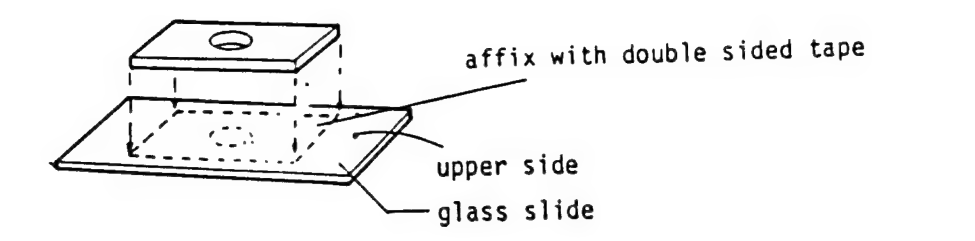


Fig. 2.

Affix a piece of black vinyl tape on the under side of the slide. Make parallel scores of 0.5mm width on the tape using a cutter knife and peel off the strips of 0.5mm width using tweezers. (see Fig. 3).

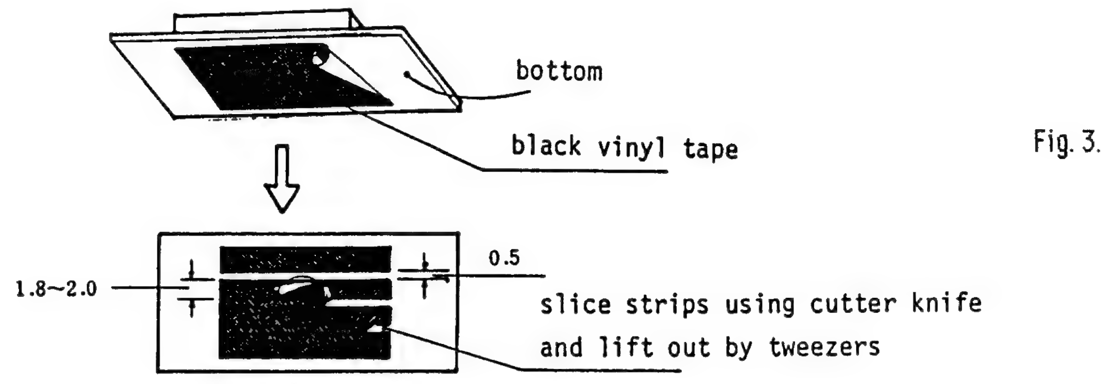


Fig. 3.

The tape puts a limitation on the light incidence by making darkfields for observation of the particles.
A cover glass over the hole makes a cell for the smoke.
In case there is no condenser lens on the microscope a detachable one can be made, and attached to the under side of the specimen stage.

THE WAY TO MAKE A DETACHABLE CONDENSER:
Put one plastic lens of 20-30mm diameter and 70-100mm focal length upon another. Put the handles for the lenses into one end of a vinyl tube, and insert one of the legs of a clothespin into the other end.
Attach the lens by the clothespin to the stage of a microscope. (see Fig. 4.)

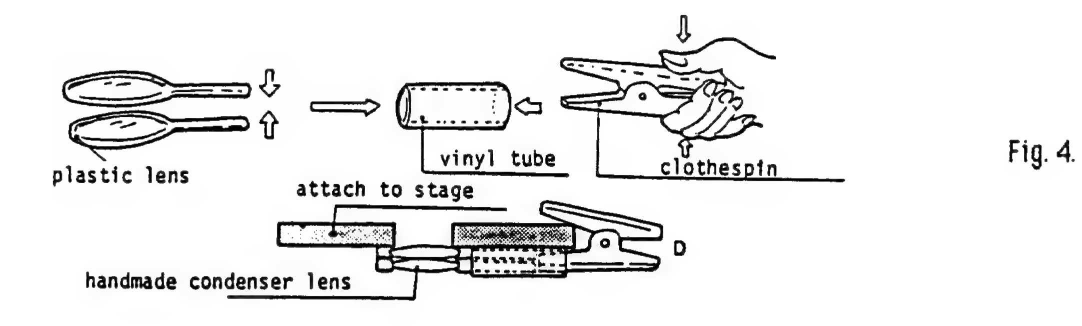


Fig. 4.

7- METHOD OF USE

(1) Set an eyepiece and objective lens on a microscope so as to obtain 100 or 200 times magnification.

(2) Attach the condenser lens to the under side of the specimen stage as shown in Fig. 4. if the microscope does not have one.

(3) Place the equipment on the stage, and focus the lens onto the edge of vinyl strips. Then remove it from the stage.

(4) Suck up the thick smoke carefully with a medicine dropper as shown in Fig. A.

(5) Release the smoke between the glass slide and cover slip carefully as shown in Fig. A.

(6) Return the cell carefully to the stage and set in the middle of the field of the microscope.

(7) Move the body-tube up slowly to focus the lens on the smoke particles at the edge of the dark parts. They will be observed more clearly at either of the edges.

(8) Move up the body-tube again and they can be observed at the part nearer to the middle of the dark belt.

(9) To observe the particles more clearly, bring the dark belt to the middle of the field of view.

(10) One release of the smoke allows an observation of the particles for three to five minutes under the light of day, or for five to fifteen minutes under a fluorescent lamp.

1- ITEM

A MICROBALANCE.

2- PURPOSE

To measure small changes in weight such as that of a plant due to transpiration.

3- INFORMATION SUBMITTED BY

Kyoto Municipal Science Center for Youth, Kyoto 612, Japan.

4- LINE DRAWING OF PROTOTYPE

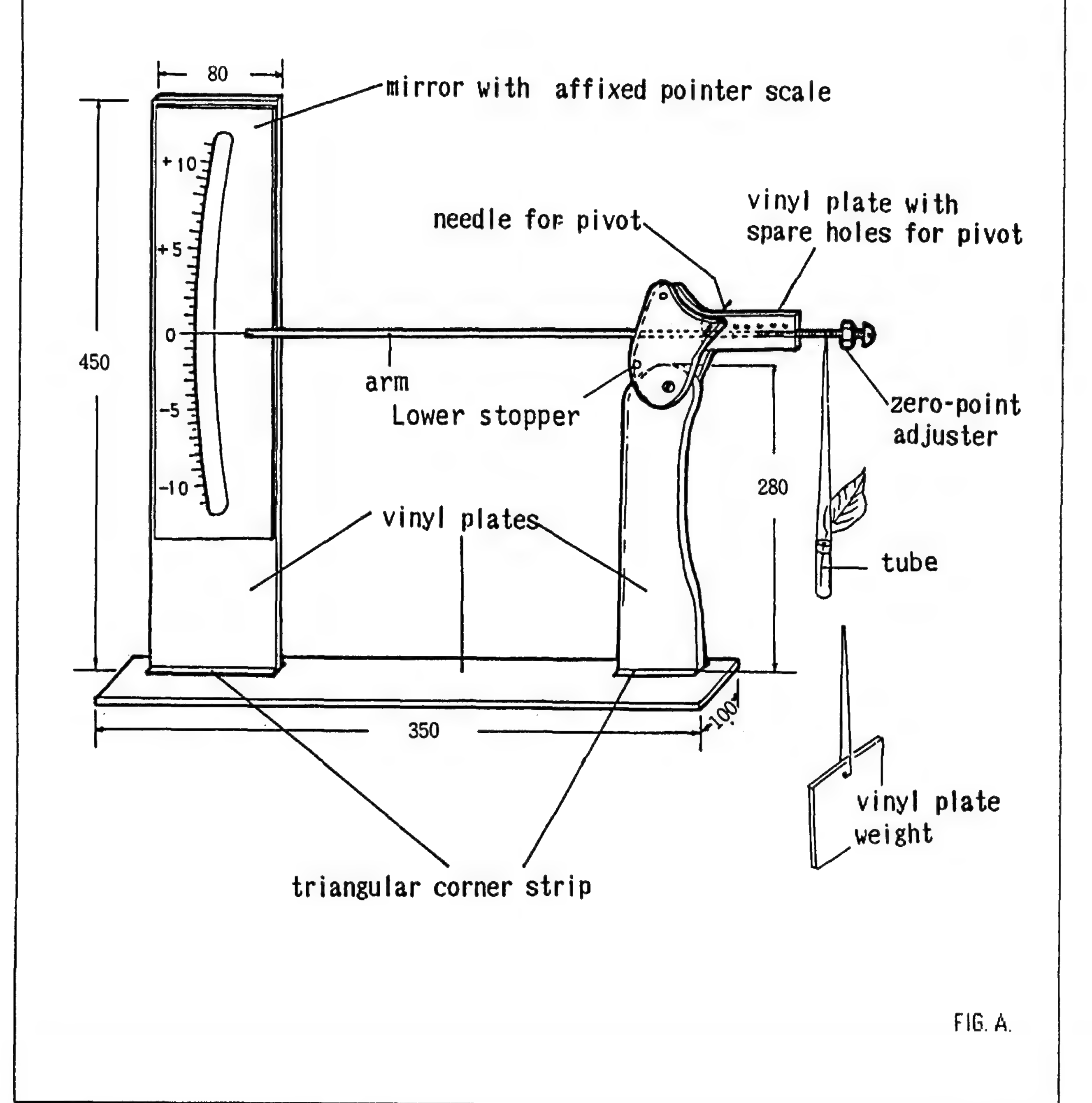


FIG. A.

5- TOOLS AND MATERIALS

(TOOLS)

Electric Hand Drill
Drill Bit (dia. 0.8mm)
Drill Bit (dia. 1mm)
Drill Bit (dia. 2mm)
Drill Bit (dia. 3mm)
Screw Driver
Taper-nosed Pliers
Cutter for Acrylic Sheet

(MATERIALS)

Cardboard (75mm x 300mm)
Milk White Acrylic Sheet (35mm x 450mm x 5mm)
Milk White Acrylic Sheet (80mm x 450mm x5mm)
Milk White Acrylic Sheet (120mm x 450mm x 5mm)
Clear Acrylic Sheet (30mm x 300mm x 8mm)
Clear Acrylic Sheet (100mm x 100mm x 3mm)..............2
Vinyl Sheet (5mm thick)
Mirror Glass (75mm x 300mm)
Hard Vinyl Resin Rod (as used for welding) (dia. 2mm. 400mm in length)
Enamel Wire
Small Cylindrical Bottle (dia. 7mm)..............1
Bolt (dia. 2mm)..............1
Nut (dia. 2mm)..............1
Needle..............1
Rubber Stopper (dia. 7mm)..............1

6- CONSTRUCTION DETAILS

(OUTLINE)

This balance is composed of an arm and pointer, scale, base, support and zero-point adjuster as shown in Fig. A.

(1) Arm

A rod of hard vinyl resin,as used for welding,and a small plate of the same resin were selected as the materials of the arm for the sake of lightness. Both are connected with each other. The arm has a pointer of enamel wire at the scale end, and a bolt and nut which works as a zero-point adjuster is attached to the small plate.

6- CONSTRUCTION DETAILS (Continued)

The small plate has also holes for the pivot above the center line of the rod so that the balance may occur at the inclination corresponding to the load. The suitable height of the pivot is 1mm above the center line in this balance. The actual positions of the pivot, and the nut of zero-point adjuster, are selected to allow for maximum adjustment during assembly. The weighing capacity of the balance is 5g and the reciprocal sensitivity is 1mg.

(2) Weights
Two kinds of weights are prepared to make calibration. The one is a plate-type weight of vinyl resin, weighing similarly to the sample. The others are of the rider type, which are made of pieces of enamel wire bent into hairpin shape. Each weight of this kind weighs 20mg and the number of them is limited to six at maximum due to the range of linearity of this balance.

(3) Scale
The pointer scale has graduations of 1mm interval and runs along the circumference of the pointer's swing. The inclination of the arm becomes less sensitive to the variation of the load as it deviates from 0° the horizontal position. Therefore, the inclination is limited to within ±30° by the stoppers and in this range it is related to the load almost linearly.

(DETAILS)
(1) Arm
Cut acrylic plate of 5mm in thickness to a size of 40 x 15mm and drill a hole of dia. 2mm longitudinally. Tap an interior thread for the bolt of dia. 3mm (for the zero-point adjuster) at one end of the hole. Make at least four holes of 1mm diameter for the pivot by drilling carefully, (see Fig. 1.) They should allow the pivot needle to roll freely.

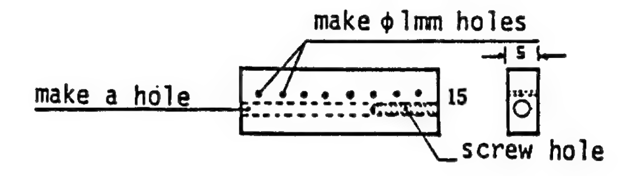


Fig. 1.

Insert a piece of enamel wire into a drilled hole at one end of the dia. 2mm vinyl rod. Insert the other end of the rod into the longitudinal hole of the vinyl plate. Attach a dia. 3mm bolt and nut to the screwed end of the hole. (See Fig. 2.)

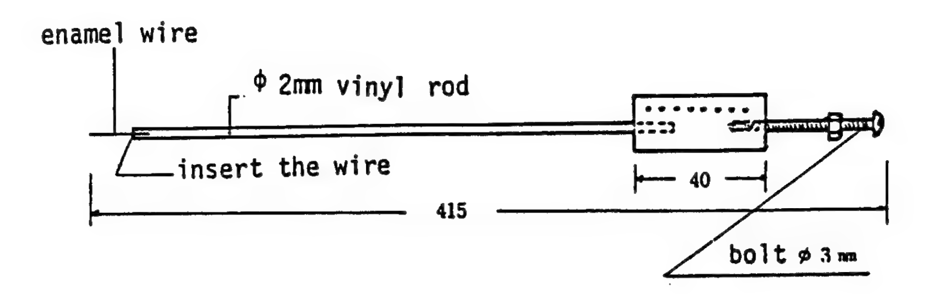


Fig. 2.

6- CONSTRUCTION DETAILS (Continued)

(2) Base and Support

Cut milk white acrylic plate of 5mm in thickness to a size of 350 x 100mm as the base.

The upper half of the support is made of two clear acrylic plates of 3mm in thickness and of the same size. (See Fig. 3). Make four holes on each of the plates, the first, dia. 0.8mm, for the pivot, the second, dia. 2mm for the bolt that connects the lower half; and the third and the forth dia. 3mm for the upper and lower stoppers.

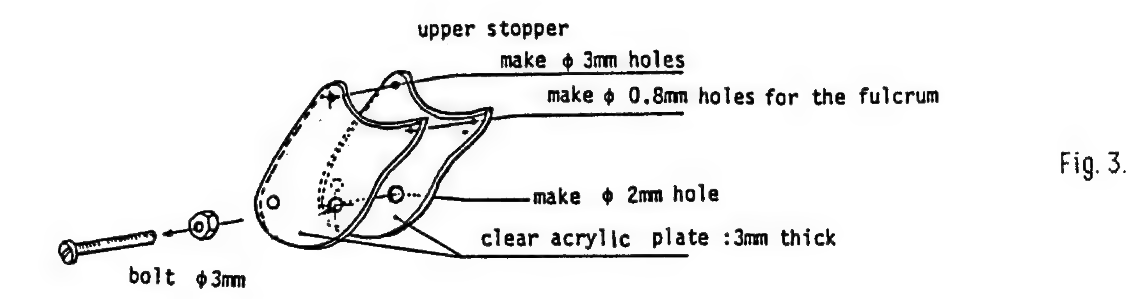


Fig. 3.

The lower half is made of a clear acrylic plate of 8mm in thickness. Make a hole for the bolt connecting the upper part. Cut out the side nearer to the object to be weighed to avoid contact. Affix it vertically on the base plate, with 5mm triangular corner pieces of acrylic resin. (See Fig. 4).

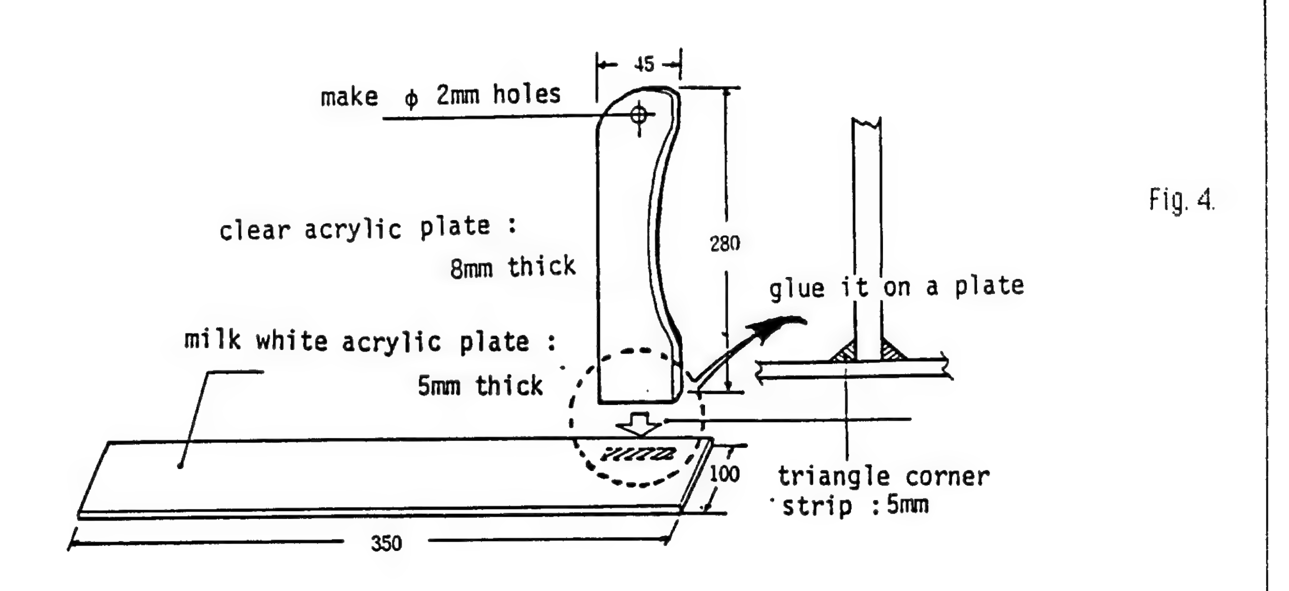


Fig. 4.

6- CONSTRUCTION DETAILS (Continued)

(3) Scale

Make the graduations for the pointer scale on 300 x 75mm sheet of drawing paper. Cut out the window along them. Glue the mirror then the scale onto their support of 450 x 80m milk white acrylic plate.

Fix them vertically on the base plate, as in the above mentioned case. (See Fig. 5).

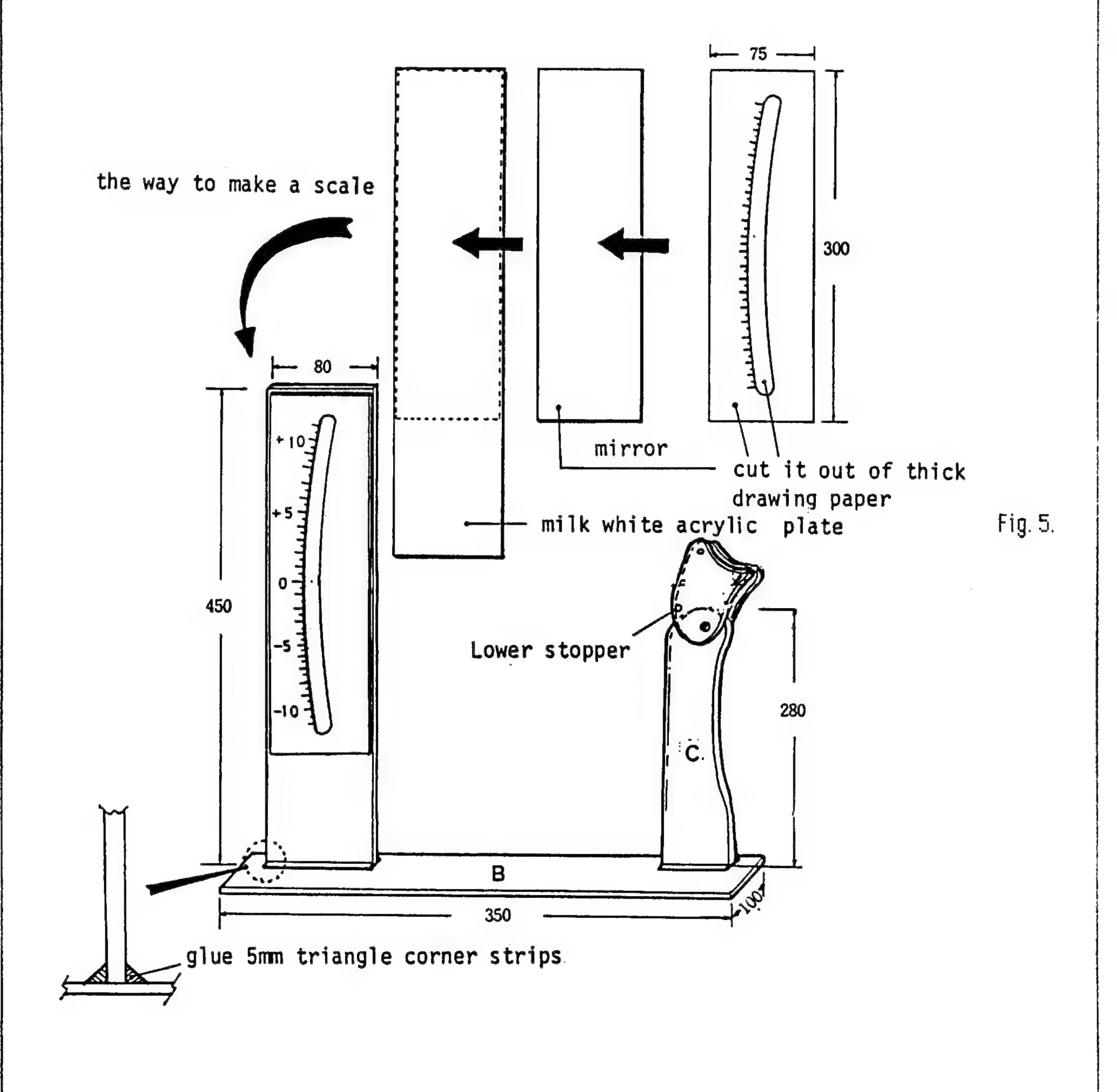


Fig. 5.

7- METHOD OF USE

The design of this balance is based on the idea of the straw balance which was introduced by the PSSC project. It is a low-cost balance of high sensitivity and great durability. It can measure not only the amount of transpiration of one leaf but also small gains or losses in weight of various objects.

(1) Calibration
Place some of the riders on the shoulder of the plate-type weight and hang all of them from the bolt at the one end of the arm. (See Fig. A). Select the pivot position which allows the arm to lay in a nearly horizontal position Read the position of the pointer on the scale when the riders are added or removed one by one, and calculate the difference of reading per 1mg.

(2) Measurement
Put a one-holed rubber stopper into a small cylindrical bottle (phial) about half-full of water, insert a leaf into the bottle, and hang them from the bolt of the balance in place of the weights.

Plot the weight change against the time and calculate the weight loss by transpiration per 1 min. The control experiment of observing the evaporation of water of the bottle without leaf, may be required according to circumstances.

Trace the contour of the leaf on section paper, read the number of sections within it, and calculate the weight loss per 1 min per 1 cm^2.

1- ITEM

TULLGREN AND BEARMANN APPARATUS.

2- PURPOSE

Collection of Soil Organisms.

3- INFORMATION SUBMITTED BY

Kyoto Municipal Science Center for Youth, Kyoto 612, Japan.

4- LINE DRAWING OF PROTOTYPE

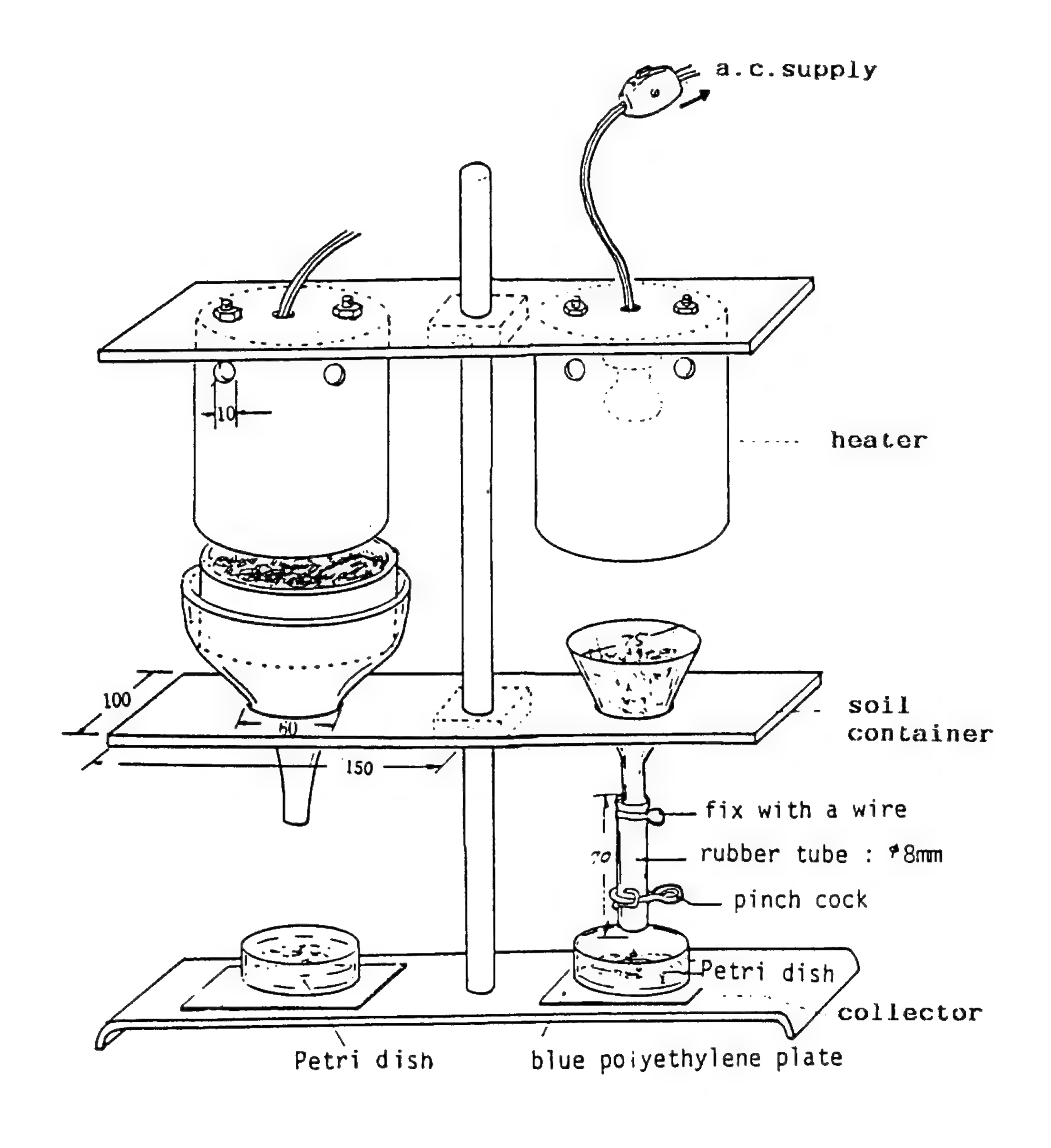


FIG. A.

5- TOOLS AND MATERIALS

(TOOLS)
Saw for cutting plastic.
Cutting knife.
Drill and drill bit (dia. 10mm)
Screw threat tap set.
Pliers.

(MATERIALS)
Acrylic sheet (300mm x 100mm x 5mm)..........2.
Acrylic sheet (50mm x 50mm x 10mm)..........2.
Vinyl pipe (tube),(i. dia. 75mm x 36mm)..........1.
Wire Gauge (Brass, 2mm mesh)..........1.
Burette stand..........1.
Aluminium Funnel (medium)..........1.
Glass funnel (dia. 75mm.)..........1.
Polyethylene Bottle (500ml)..........1.
Petri dish..........2.
Blue tile..........2.
Heater (40W reflector lamp)..........2
Lamp holder..........2.
Cable, switch and plug..........2.
Rubber tube (dia. 8mm x 70mm)..........1.
Pinch cock..........1.
Epoxy resin adhesive
1.2 dichloroethylene
Iron wire.

6- CONSTRUCTION DETAILS

See page 3.

6- CONSTRUCTION DETAILS (Continued)

(OUTLINE)

Each of the two pieces of equipment are composed of four parts: heater, soil container, collector, and stand. (See Fig. 1.)

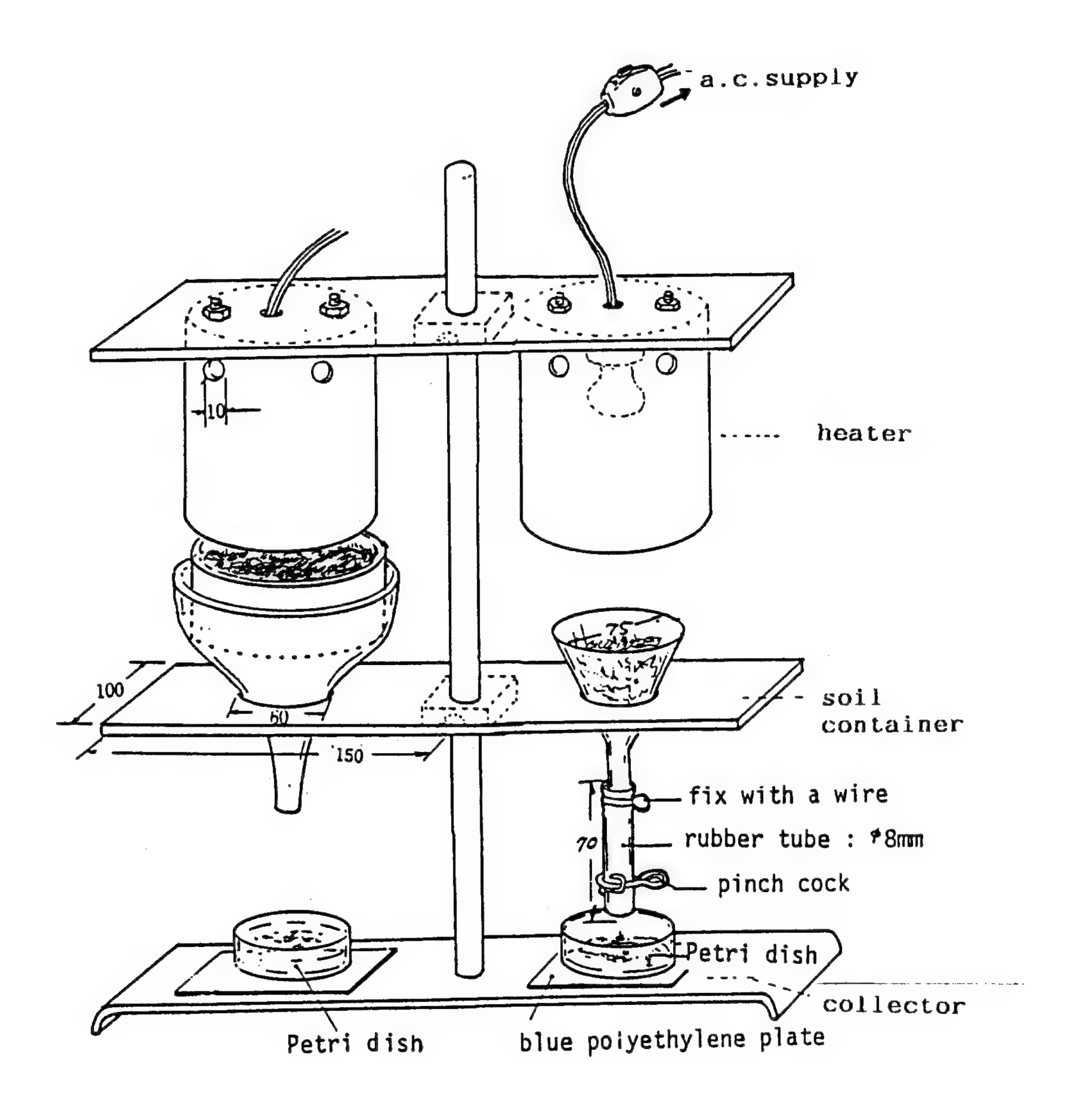


Fig. 1.

6- CONSTRUCTION DETAILS (Continued)

HEATER

The lamp shade is made from a wide-mouthed polyethylene bottle of 500ml by cutting its top off just below the shoulders. Drill six holes (dia. 1cm) around it to let the steam,vaporized from the soil sample,escape. As the heat source, a 40W reflector lamp is attached to the bottom of the bottle . (See Fig. 2.).

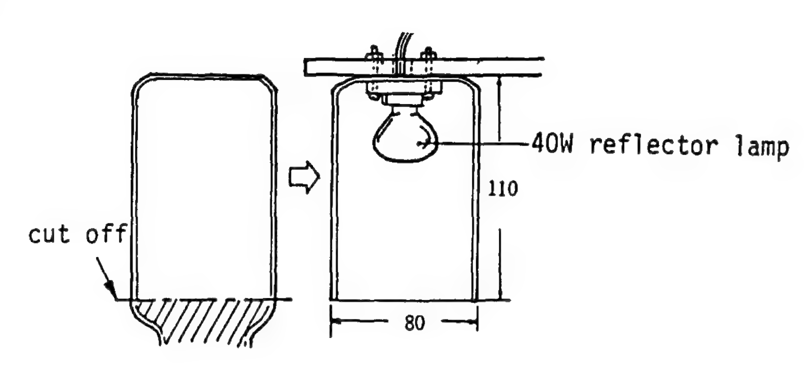


Fig. 2.

DETAILS OF SOIL CONTAINERS IN DRY CONDITIONS (Fig. 1. Left)

A soil container is made of hard vinyl pipe (7.5cm inner diameter) with brass wire gauze of 2mm mesh glued with epoxy adhesive on its bottom. (See Fig. 3).

The animals in the soil go through this gauze and fall down through an aluminium funnel into the collector.

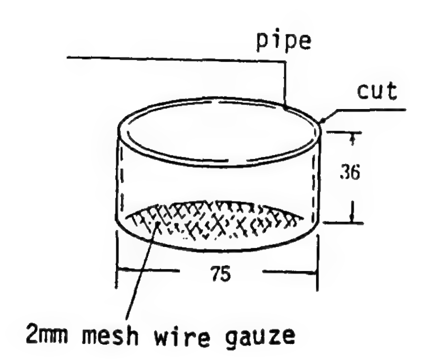


Fig. 3.

DETAILS OF SOIL CONTAINER IN WET CONDITIONS (Fig. 1. Right)

A glass funnel of about 7.5 cm diameter is filled with water by closing the rubber tube attached to its outlet with a pinchcock.

6- CONSTRUCTION DETAILS (Continued)

COLLECTOR

A Petri dish containing a small amount of water is used to catch the animals.
A blue polyethylene plate is put under it so that the floating animals on the water are clearly observed.

STAND

The above mentioned parts are placed on a stand. In this case, a burette stand was modified. The racks are made of two acrylic plates of 5mm thickness, one of the heaters, and the other for the soil containers. A small acrylic square of 10mm in thickness is glued to the center of each plate with 1.2-dichloroethylene as the base for the bolt that fix the rack to the pole. (See Fig. 4.)

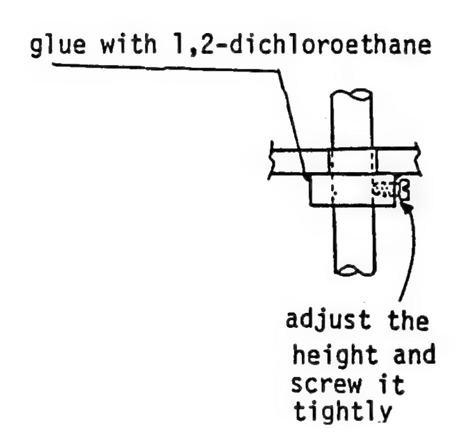


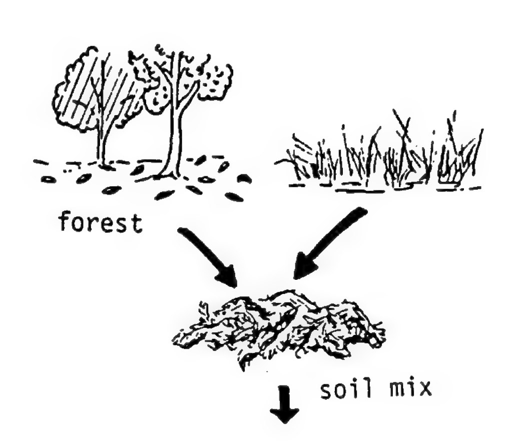
Fig. 4.

A stand holding a pair of collecting equipment for dry and wet conditions is convenient as shown in Fig. 1.

7- METHOD OF USE

This equipment will be used after hand sorting of larger animals in the sample soil.

(a) Collector for dry conditions.
Put a half of the sample soil, about 50ml into the soil container, taking care not to press the soil.



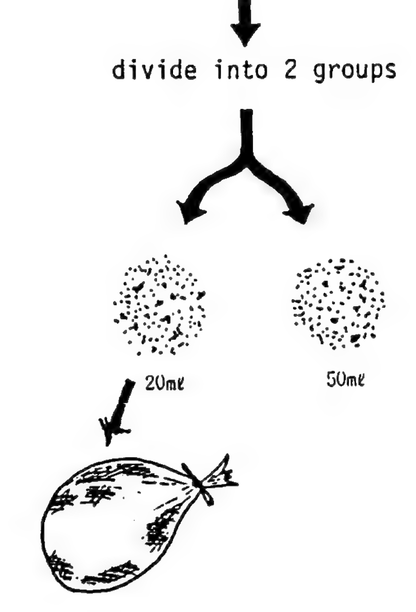
Switch on the heater after all the preparations are done. Then observe and count the animals, falling from the soil to the collector, by the naked eye, during the heating for about 20 mins.

Shut off the heating current and observe and count them using a magnifier.

(b) Collector for wet conditions.
Wrap up the soil sample, of about 20ml in volume, in a piece of nylon cloth about 12cm square(from an old pair of stockings). Close with a rubber band. Put the parcel into the glass funnel, and cover it completely with water. Heat it for about 40min. Open the pinchcock of the funnel and run the water with the animals into the catching dish. Observe and count them.

hand sorting

divide into 2 groups



1- ITEM

RESPIRATION APPARATUS.

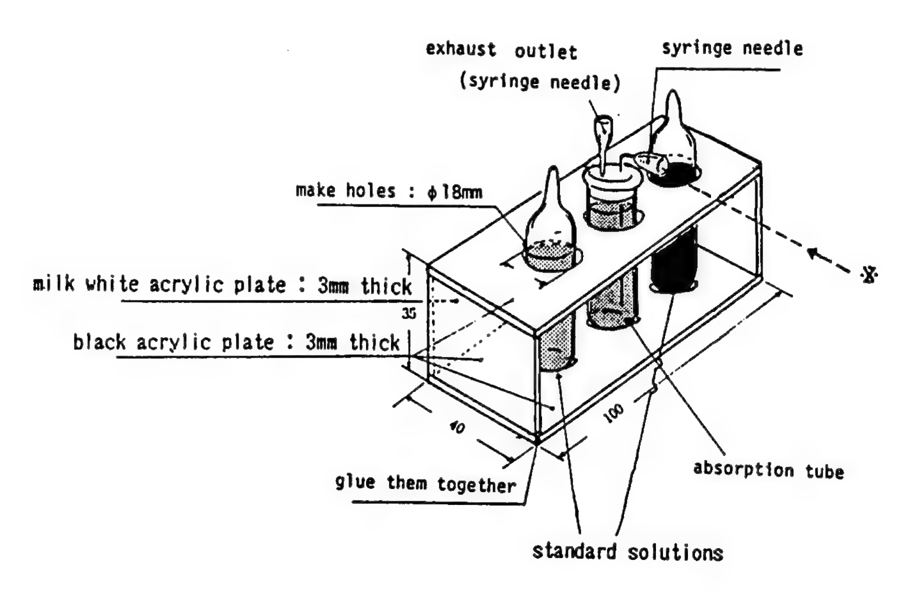
2- PURPOSE

To determine the volume of carbon dioxide discharged by Plants etc. during respiration.

3- INFORMATION SUBMITTED BY

Kyoto Municipal Science Center for Youth, Kyoto 612, Japan.

4- LINE DRAWING OF PROTOTYPE



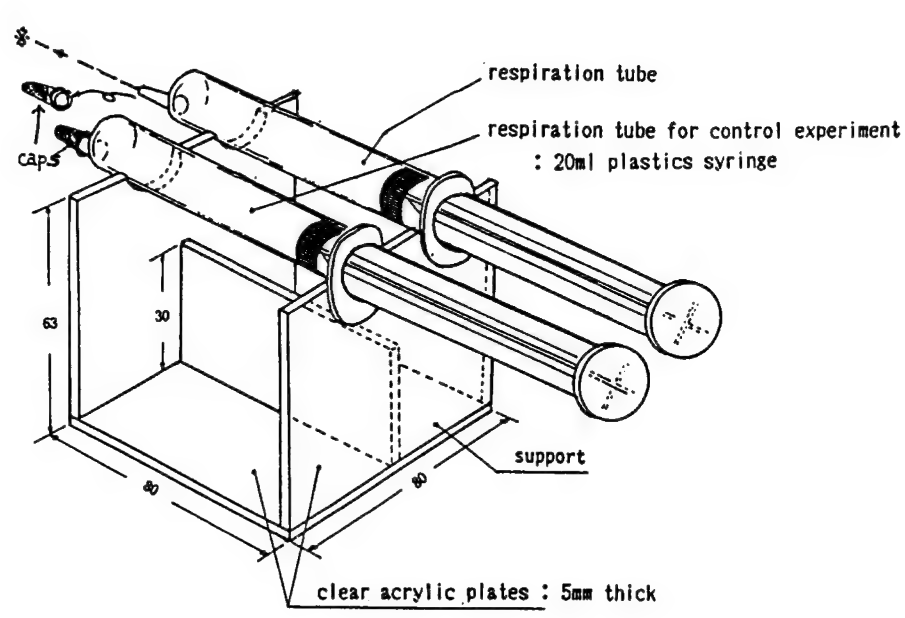


FIG. A.

5- TOOLS AND MATERIALS

(TOOLS)
Electric Drill
Drill Bit (dia. 18mm)
Hacksaw

(MATERIALS)
Clear Acrylic Sheet (80mm x 80mm x 5mm)
Clear Acrylic Sheet (80mm x 63mm x 5mm).. 2
Clear Acrylic Sheet (80mm x 30mm x 5mm)
Black Acrylic Sheet (40mm x 35mm x 3mm).. 2
Black Acrylic Sheet (40mm x 10mm x 3mm)..2
Milk White Acrylic Sheet (100mm x 35mm x 3mm)
0.05% Solution of Bromothymol Blue..50ml
Acrylic Adhesive.

Set of Ten Tubes Containing a Standard pH Series of
Solution Coloured by Bromothymol Blue..1
Empty Container of the Standard Solution...1
Plastic Cap for the Container...1
Injection Syringes (20ml. clear and disposable,
for medical use)..2
Cap for Syringe.. .2
Injection Needle (Size 1/4, 6cm in length)..2
Dropping Bottle...1

6- CONSTRUCTION DETAILS

This equipment is composed of respiration tubes, their support, an absorption tube, a visual colorimeter and standard series of colour solution of Bromothymol Blue.

(1) The respiration tubes
Two disposable injection syringes for medical use, made of clear plastic, are used. One of them is for the control experiment. The capacity of the syringes should be 20ml or smaller, depending on the test samples. A test sample is put directly into one of the tubes, and it can be easily observed as the tube is clear.

7- METHOD OF USE

(2) The Support

The support is made of clear acrylic plates (See Fig. 1). The two respiration tubes are laid horizontally on it side by side. (See Fig. A).

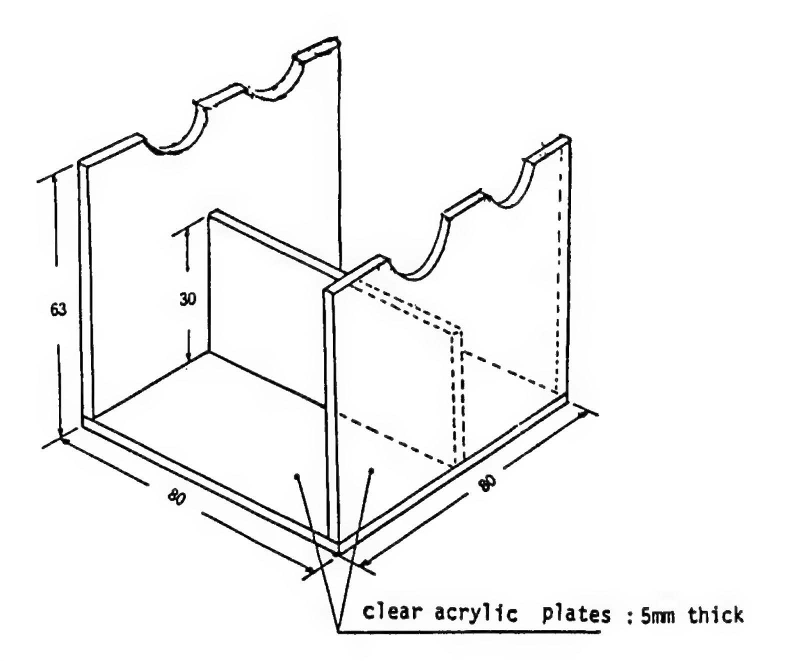


Fig. 1.

(3) Absorption Tube

The tubes are of the same size and material as those for the standard colour solutions, and should have a graduation around them at the 5ml level.

The tube contains 5ml of water to which are added a few drops of Bromothymol Blue solution, and is covered with a plastic cap through which two syringe needles are inserted into the tube. One of the needles is for introducing the air containing carbon dioxide from each of the respiration tubes. The needle is bent gradually to a right angle in the middle of it, and its pointed end is smoothed by a file to avoid accidents. The other needle is the outlet for the remaining components of the air, and the needle is cut off to an appropriate length. (See Fig. 2).

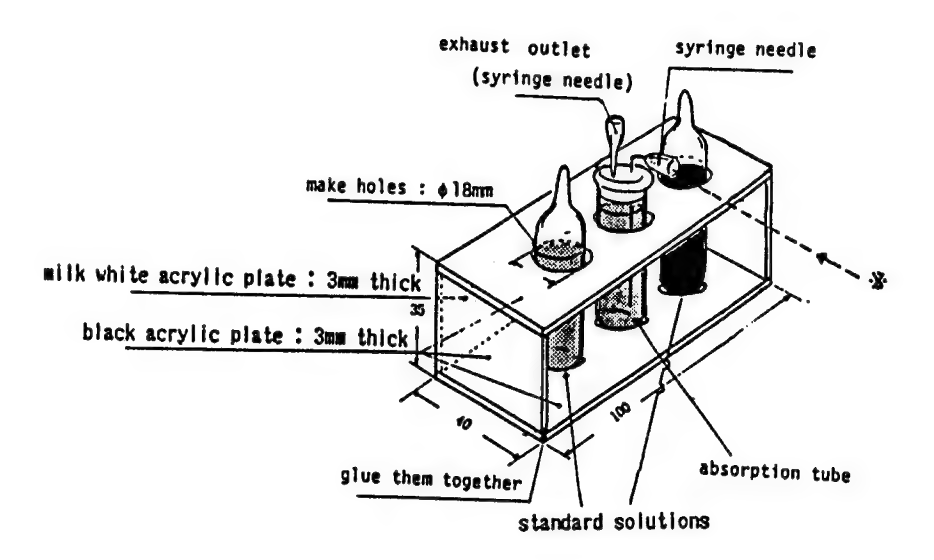


Fig. 2.

6- CONSTRUCTION DETAILS (Continued)

(4) Visual Colorimeter

The stand is constructed as shown in Fig. 2.

The sample solution of carbon dioxide coloured by Bromothymol Blue is compared with two standard solutions of nearest tints, on this colorimeter, to determine its pH value. The tubes containing these two kinds of solutions are placed in front of the milk-white plastics board (through which the light is transmitted) for careful comparison. (see Fig. 3).

(5) Standard pH solution (coloured by Bromothymol Blue).

The standard series of these solutions are obtained commercially. Alternatively, it can be made by using Bromothymol Blue and buffer solutions of known pH values.

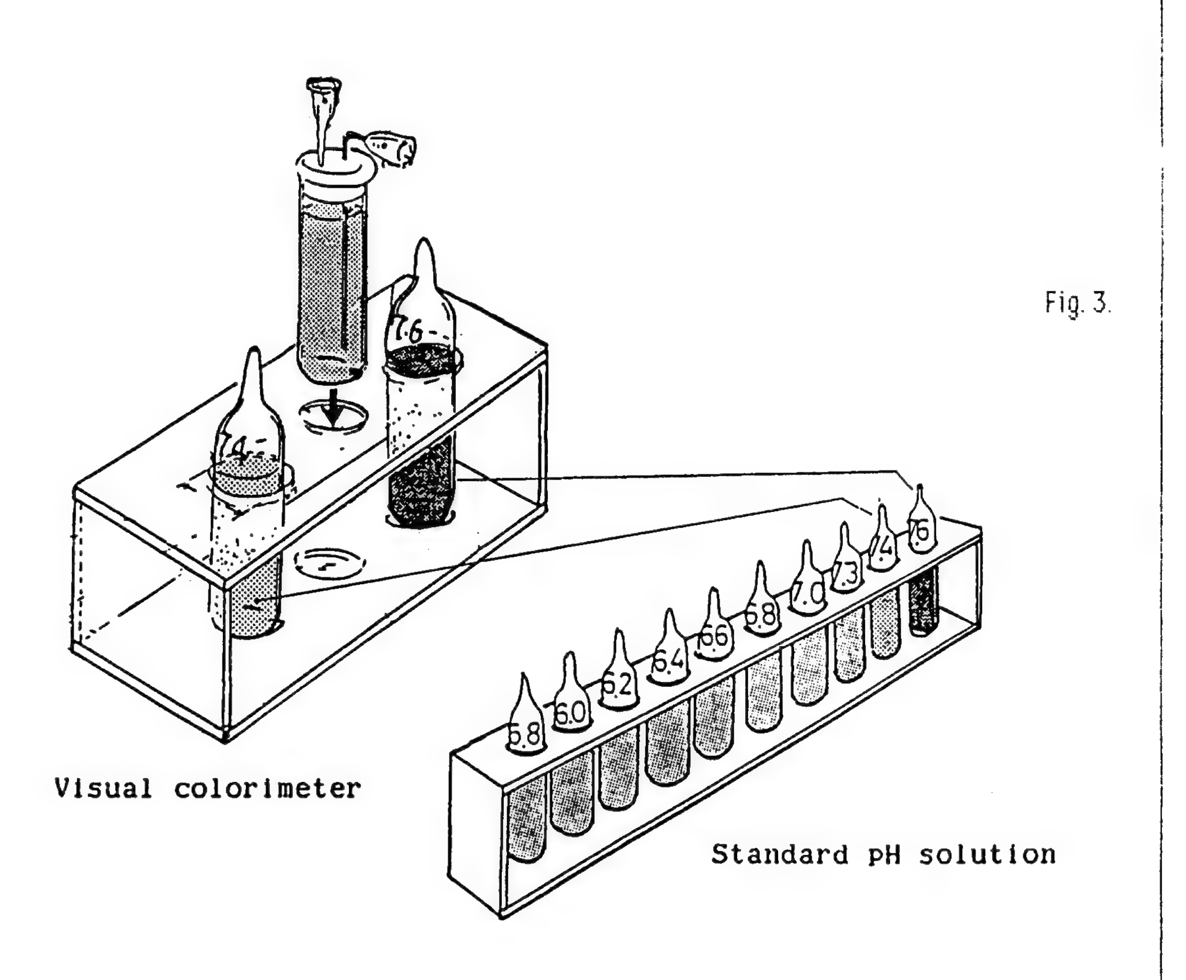


Fig. 3.

7- METHOD OF USE

This equipment is used for measuring the volume of carbon dioxide discharged from plants, soil, or insects by the visual colorimetry method using Bromothymol Blue solutions. Test samples are placed in an injector (here called a respiration tube) and kept at a fixed temperature for a given period of time. The experiment is easily performed within a short time.

(1) Compare the colour of the absorption tube with the standard series to estimate its initial pH.
(2) Put the sample into a capped respiration tube, and hold it at a controlled temperature for a prescribed period of time; 10min for instance.
(3) Connect the respiration tube to the inlet needle of the absorption tube and introduce the air sample into it. Since carbon dioxide dissolves slowly in water, the air should be introduced as slowly as possible as a stream of fine bubbles to make a large area of contact. (Count at least one minute for 5ml of air).
(4) After a known amount of air has been introduced into the absorption tube, estimate the final pH.
(5) Repeat the steps (1) to (4) for the control experiment, using the empty respiration tube and an absorption tube of fresh solution.
(6) Reduce the final pH values to the concentrations of carbon dioxide in the respiration tube with use of the reduction diagram previously drawn. Fig. 5. shows an example of such a diagram in the case of the initial pH of 7.6. The difference of the concentration obtained from the sample over the control will allow an estimate to be made of the amount of carbon dioxide discharged from the sample

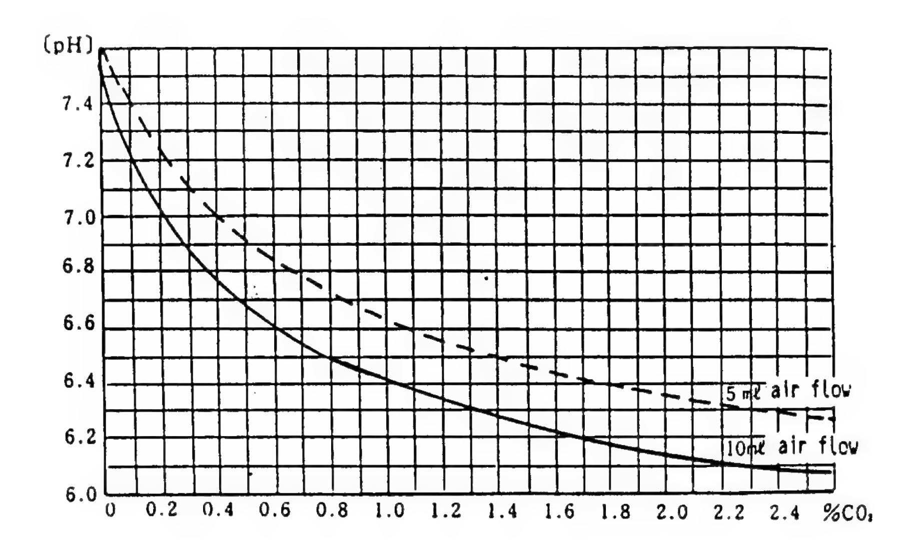


Fig. 5.

(APPLICATIONS)

The respiration of various samples, such as flowers, leaves, buds, germinating seeds, worms, and a volume of soil, may be observed with use of this apparatus. A strip of filter paper impregnated with yeast and glucose will show the generation of carbon dioxide by fermentation.

It is interesting to observe respiration volumes at different stages of the germination of seeds and the metamorphism of the insects, and the equipment clearly demonstrates that green leaves consume carbon dioxide in the light, while they discharge it in the dark.

1- ITEM

GAS GENERATOR (Type A)

2- PURPOSE

To generate gas by a chemical reaction

3- INFORMATION SUBMITTED BY

Kyoto Municipal Science Centre for Youth, Kyoto 612, Japan.

4- LINE DRAWING OF PROTOTYPE

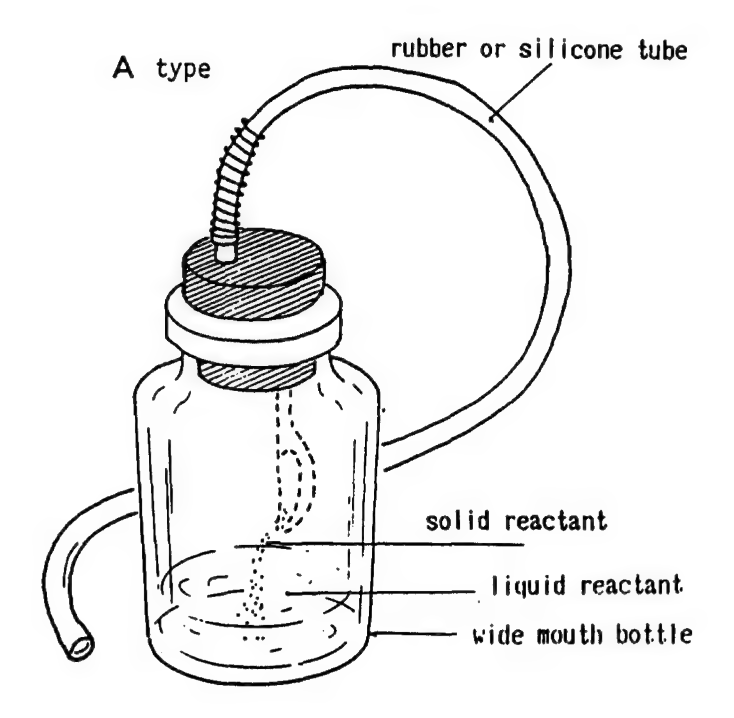


FIG. A.

5- TOOLS AND MATERIALS

(TOOLS)
Wire Cutters.
Screw Driver.
Metal Rod (dia. 6mm).
Cork Borer.

(MATERIALS)
Rubber Stopper. Size 12..1.
Plastic Spoon..1.
Wide Mouth Bottle (125ml).......................................1.
18-8 Stainless Steel Wire (dia. 0.5mm, 50cm length).
Glass Tube (dia. 7mm, 70mm length).

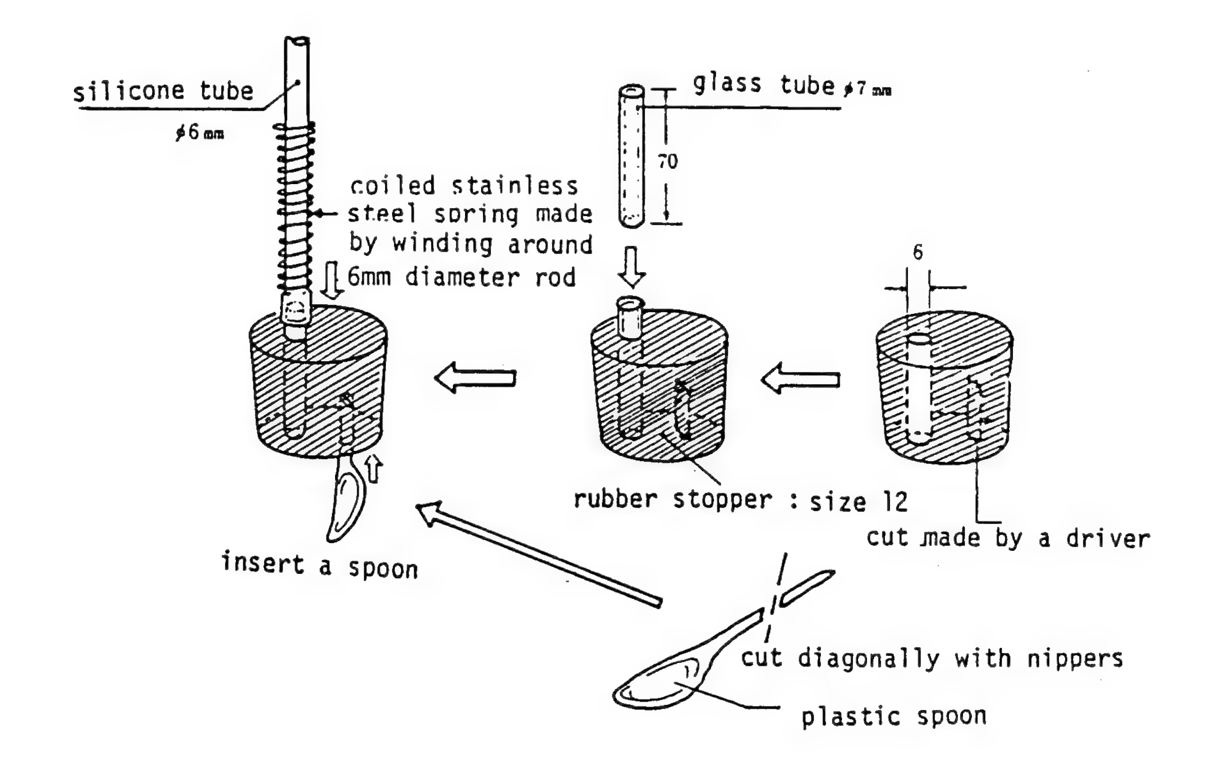
6- CONSTRUCTION DETAILS

(OUTLINE)
A rubber stopper with a short piece of glass tubing inserted through, and a plastic spoon attached to its inner side, is put into a wide mouthed bottle. To the outer edge of the glass tube a long silicone tube is connected, as the outlet of the gas (Fig. A.).

6- CONSTRUCTION DETAILS (Continued)

(DETAILS)
Make a hole of dia. 6mm in a rubber stopper (No. 12), and make a piece of glass tubing (0.7mm x 70mm) into it. Make a cut on the lower side of the stopper with the edge of a screw driver. Cut the handle of the spoon diagonally in the middle of it with nippers, and put its edge into the cut. A detent on the handle made by filing will prevent the spoon from falling down.

Connect a rubber (or vinyl or silicone) tube (dia. 6mm) to the outer edge of the glass tubing. A coiled spring of stainless steel around the connected end of the rubber tube will prevent the bending of the tube to stop the path of the gas.



7- METHOD OF USE

This design enables the reaction to be started at any time after it is closed tightly, and it is suitable for measuring the amount of generated gas at successive stages of the reaction.

(1) Put a graduated cylinder filled with water upside down into a water trough.

(2) Pour the prescribed volume of liquid reactant into the wide mouthed bottle.

(3) Put the free end of the longer tube into the graduated cylinder, taking care of its bending that narrows the path of the gas.

(4) Take a known amount of solid reactant on a spoon, and put the stopper with things attached to it tightly into the bottle laid obliquely.

(5) Stand up the bottle in order to start the reaction.

(6) Read the level of water in the cylinder successively at appropriate intervals of time.

1- ITEM

GAS GENERATOR. (Type B)

2- PURPOSE

To generate gas by a chemical reaction

3- INFORMATION SUBMITTED BY

Kyoto Municipal Science Centre for Youth, Kyoto 612, Japan

4- LINE DRAWING OF PROTOTYPE

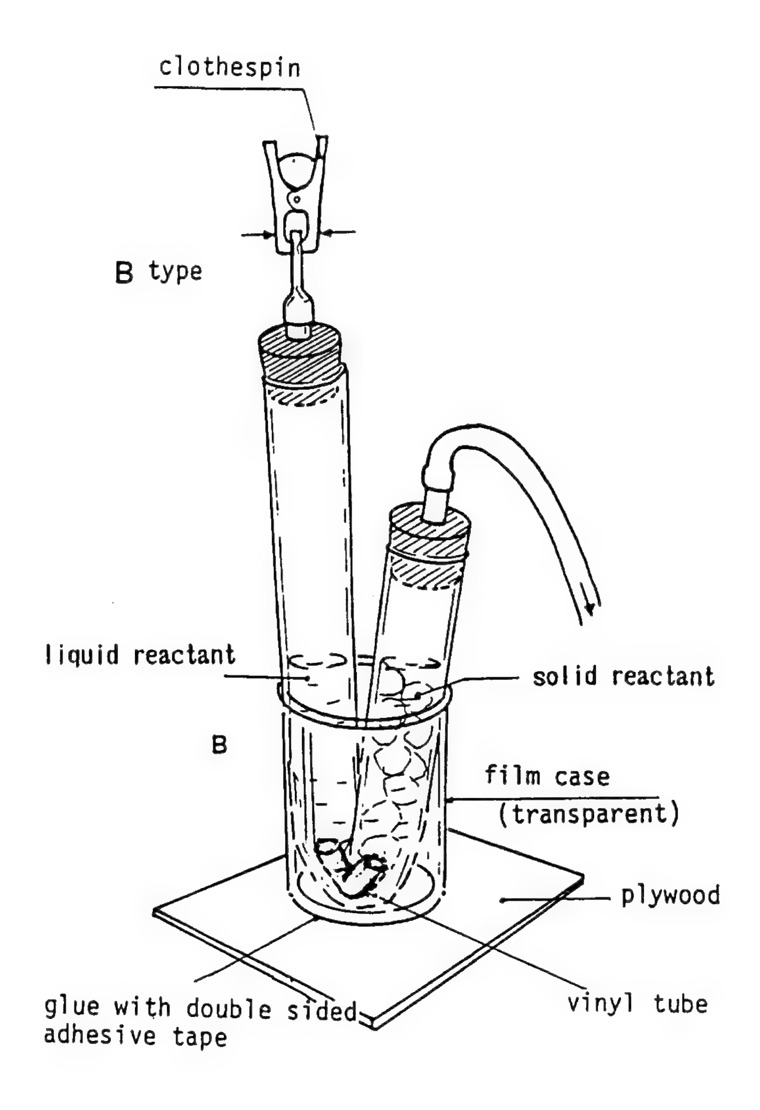


FIG. A.

5- TOOLS AND MATERIALS

(TOOLS)
Cork Borer.
Bunsen Burner.
Triangular File.
Diagonal Cutting Nippers.
Double Edged Saw.
Cutter.

(MATERIALS)
Clear Vinyl Hose (dia. 14mm)
Vinyl Tube (dia. 3mm)
Rubber Tube (dia. 3mm)
Double Sided Adhesive Tape.
Plywood (70mm x 70mm x 5mm)
Rubber Stopper (Size 2)..2
Empty Film Case (35mm. clear plastics)................1
Clothespin..1

6- CONSTRUCTION DETAILS

(OUTLINE)
A clear vinyl hose with a one-holed rubber stopper at each end is bent to a V-shape of unequal arms. The solid reactant stays in the shorter arm, while the liquid and gas can move freely between both arms through a piece of narrow tubing laid across the bend. The rubber tube on the top of the longer arm is short and closed with a clothespin and that from the shorter arm is the outlet for the gas (Fig. A.)

6- CONSTRUCTION DETAILS (Continued)

(DETAILS)
Put a piece of vinyl tubing (outer diameter of 5mm. 30mm in length) into each of two rubber stoppers of No. 2.

Connect a rubber tube with an inner diameter of 4mm to each of the vinyl tubes, one of them being 3cm long, and the other long enough to lead the gas to the collecting bottle. Cut off vinyl hose of 25cm in length, and put the rubber stopper into both ends. Lay a piece of vinyl tubing (dia. 3mm. 30mm in length) at the part of the hose 10 cm distant from its one end into which the stopper with the longer tube is put, and bend the hose at the position to a V-shape (see Fig. 1). Attach an empty film case of clear plastics to a board of plywood with double sided adhesive tape, and put the V-shaped hose into it.

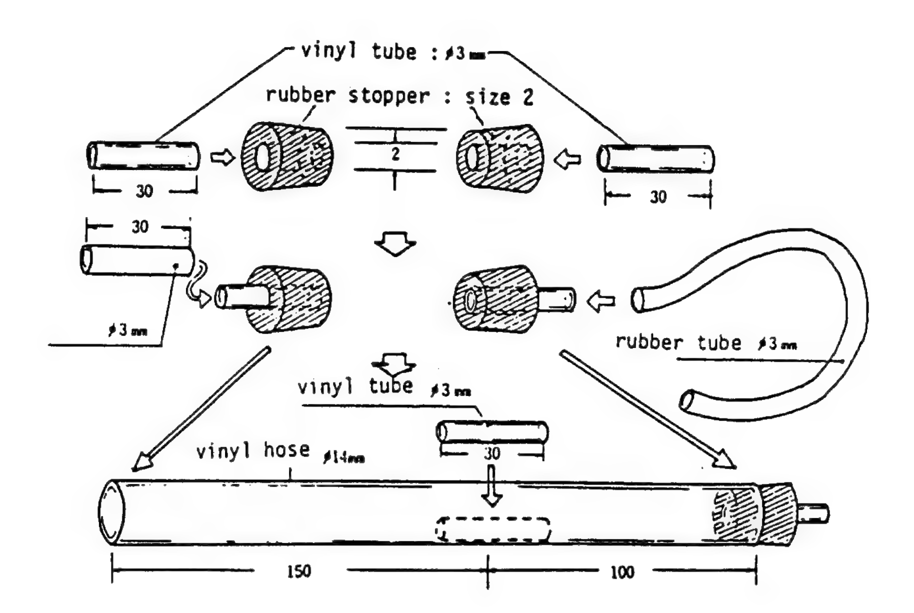


Fig. 1.

7- METHOD OF USE

This design is a modification of Kipp's generator, and is convenient for obtaining small amounts of gas repeatedly. In addition, it is easily constructed with use of low-cost materials, requires smaller amounts of chemicals, and simpler operations with no danger from explosions.

(1) Put the collecting bottle filled with water upside down in a water trough.

(2) Put the solid reactant into the shorter arm and insert the rubber stopper, with the longer tube, into its mouth.

(3) Pour the liquid reactant into the hose from the end of the longer arm and fill up to one half maximum. If a vigorous reaction is expected, the amount should be reduced to a safe level.

(4) Insert the rubber stopper, with the shorter tube, into the mouth of the longer arm of the hose, and close the open end of the tube with a clothespin. The generated gas will be sent to the collecting bottle.

(5) When the required amount of the gas has been collected, change the position of the clothespin to the longer tube. The gas will force the liquid into the longer arm of the hose, and the reaction will be stopped.

(6) To obtain the gas again, draw out the free end of the longer tube from the collecting bottle to the atmosphere and remove the clothespin to equalise the levels of water in both arms. Then close the shorter tube.

1- ITEM

DEW POINT APPARATUS.

2- PURPOSE

To determine the dew point of atmospheric air.

3- INFORMATION SUBMITTED BY

Kyoto Municipal Science Center for Youth, Kyoto 612, Japan.

4- LINE DRAWING OF PROTOTYPE

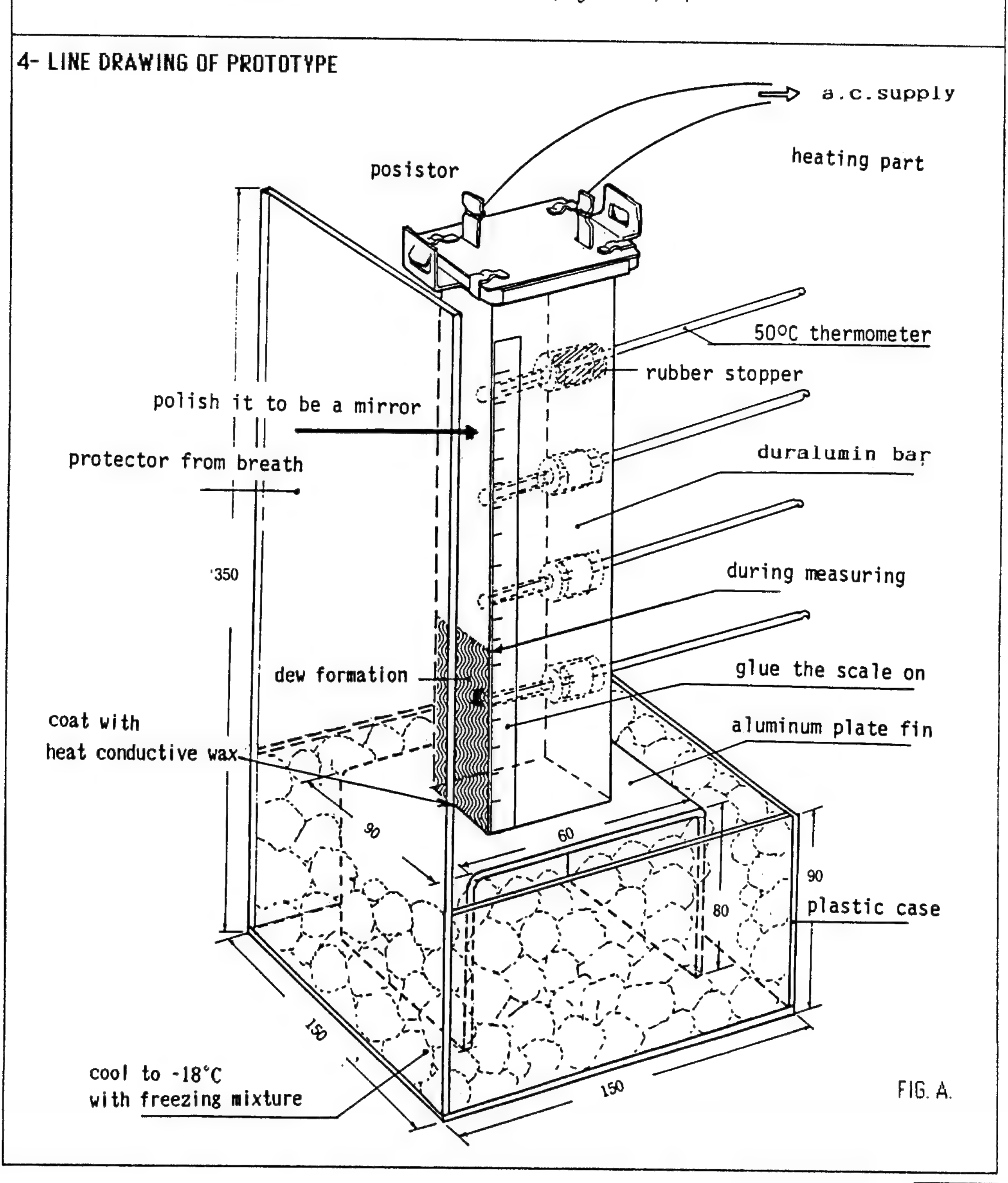


FIG. A.

5- TOOLS AND MATERIALS

(TOOLS)

Hack Saw
Tin Snips
Sets of Screw Thread Taps
Electric Hand Drill
Drill Bit (dia. 3.5mm)
Cutter for Acrylic Plate
Felt Sheet (pasted on a board for polishing)
Drill Bit (dia. 4mm)
Drill Bit (dia. 5mm)
Drill Bits (dia. 6mm)
Drill Bit (dia. 10mm)

(MATERIALS)

Duralumin Rod (rectangular 200mm x 30mm x 20mm)............................1
Aluminium Plate (220mm x 90mm x 1mm)..1
1.2-Dichloroethane
Heat-Conductive Grease.
Abrasive (for polishing/finishing)
Ice...500g
Table Salt..500g
Bolt (dia. 4mm. 10mm in length)..2
Heating Element...1
Polishing Cloth (for glasses)
Thermometer (-20°; +50°)...5

6- CONSTRUCTION DETAILS

(1) TROUGH FOR FREEZING MIXTURE

Make a trough for the freezing mixture with acrylic plate of, say, 3mm in thickness. One of the side plates should be high enough to stop the breath of the observer from reaching the duralumin bar when the height of the upper limit of the dew formation is read(See Fig. 1.)

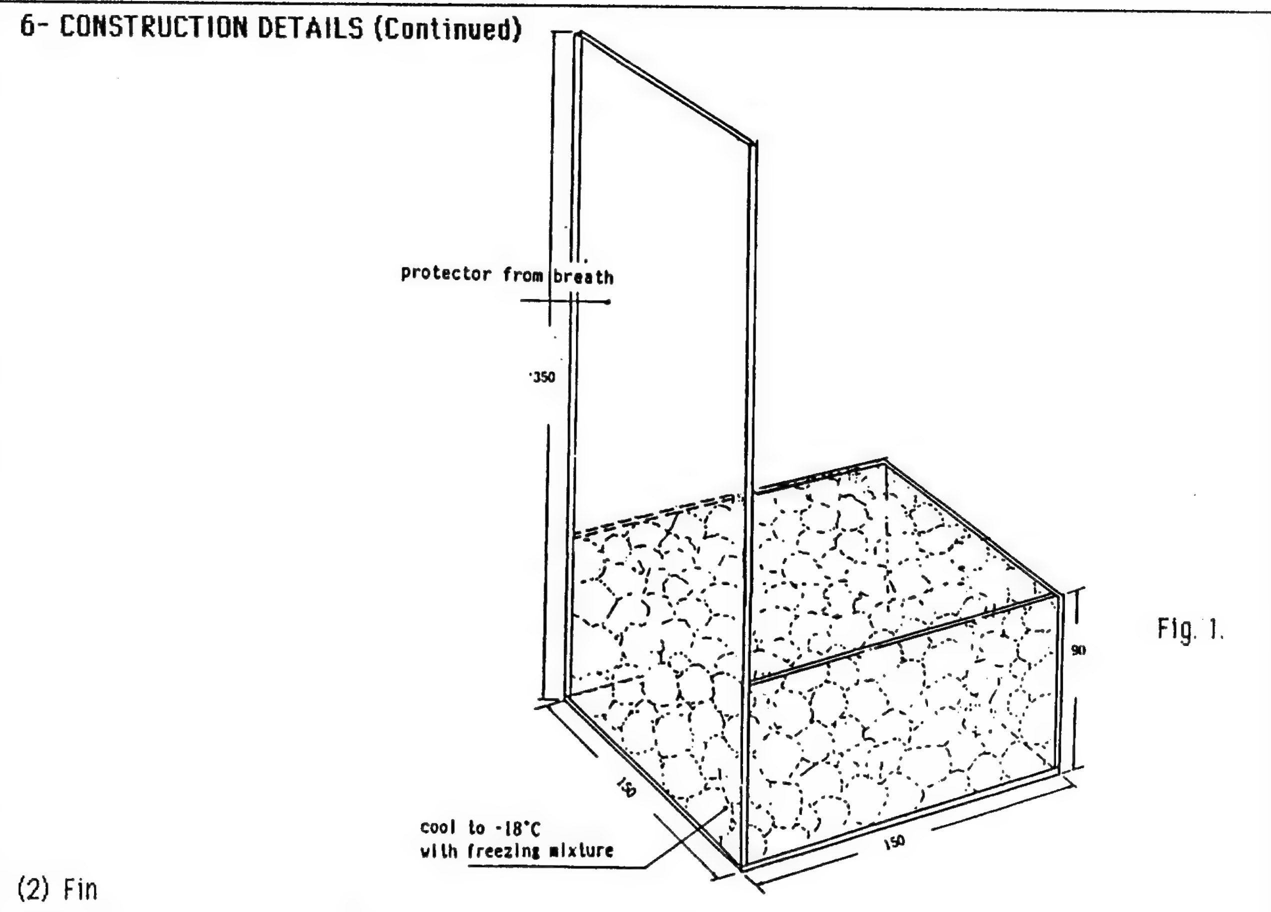


Fig. 1.

(2) Fin

Construct the fin, as shown in Fig. A., from a piece of aluminium plate of size 220mm x 90mm x 1mm. Drill 2 holes for attaching the fin to the bar.

(3) Duralumin Bar

The duralumin bar used in this equipment is 200mm x 30mm x 20mm in size, which has a sufficient heat capacity to stabilize the temperature distribution in it.

Make four holes for inserting the thermometers and the one-holed rubber stoppers transversely to the bar, and two holes for the screws to attach the cooling fin to the bar on the bottom side. (See Fig. 2).

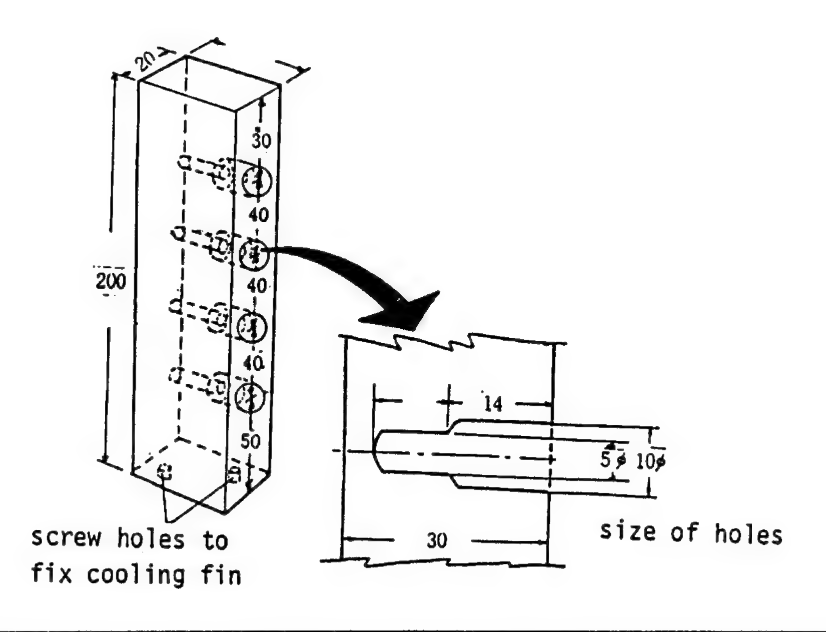


Fig. 2.

Polish the top and bottom faces with emery paper to obtain flat surfaces.

Polish the opposite side to the holes accepting thermometers with an aluminium oxide powder(used to make a thin section of rock),on the felt plate until the face becomes dim . (See Fig. 3) Then rub it with the glass cloth smeared with "Car Wax" to get a mirror like face.

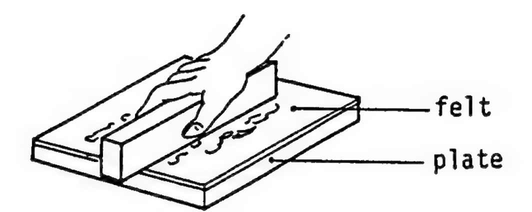


Fig. 3.

Coat the bottom face of the bar with heat conductive grease when attaching the fin to it. Coat also the bulbs of the thermometers when they are inserted to the bar.
Affix a scaled vinyl rule to the bar as shown in Fig. A.

(4) Heater
The posister used was a semi-conductor heating element (used to sublimate mosquito-fumigant), (see Fig. 4), and operating on AC current. The heating element of an electric soldering iron can also be used as the heater. However, it may require a variable resistor to drop the input voltage. (In the case of a 60W soldering iron, it may be about 40V on a 100V a.c. supply (somewhat higher in summer, lower in winter). Glue the heater to the top face of the duralmin bar with quickly curing adhesive.

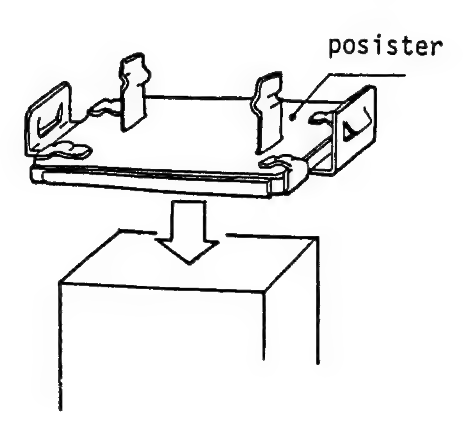


Fig. 4.

(5) Freezing mixture
Wrap several blocks of ice in a piece of strong cloth, and tap a stick evenly on them to obtain pieces of about 5mm in size. Add one volume (500g) of table salt to two volume (500g) of the ice layer by layer. Stir them with a stirring rod, and they cool to the temperature of about -20°C. In summer, the salt may be unnecessary.

7- METHOD OF USE

Usually, the low temperature for dew formation is obtained by the evaporation of ether, but the method requires care to avoid uncomfortable smells and accidents due to its flammability. Furthermore, the formed drops of dew extinguish so quickly that the experiment is often inadequate as a demonstration to many pupils.

This equipment enables continuous measurements of the dew point to be made without using ether. In addition, it can clearly show the fact that moisture in the atmosphere becomes dew on the surface of solid matter when the temperature is below the dew point.

The bottom aluminium fin in the freezing mixture of salt and ice is cooled to about -18°C while the top is heated with the heater, (a posister used to sublimate mosquito-fumigant), which keeps the temperature to about 25°C in summer and 15°C in winter, therefore the temperature gradient along the duralumin bar is kept linear and steady.

The drops of dew appear on the surface of the duralmin bar and their upper limit makes a clear horizontal borderline around the middle of the bar.

This state lasts for about one hour and half in winter and one hour in summer according to the time of duration of the freezing mixture.

Among four thermometers inserted into the duralmin bar at equal intervals, two give the temperatures just above and just below the dewpoint, which is estimated by interpolation from the both temperatures.

(1) Dip the aluminium fin into the freezing mixture, and complete the heating circuit.

(2) Read the scale at the position of the upper limit of the range which allows the drops of dew to condense, and at the positions of the thermometers. The temperature at the limit is the dew point of the atmospheric air.

(3) Read the thermometers just above and just below the limit.

(4) Calculate the dew point by proportional allocation based on the results obtained at (2) and (3).

7- METHOD OF USE (Continued)

(EXAMPLE OF RESULT)

Date		
Weather	fine	
Temperature. °C		
atmosphere	25.8	
freezing mixture	-15	
positions in the bar	6.5	(50mm)
	9.2	(90mm)
	11.8	(130mm)
	14.5	(170mm)
upper limit of the dew		120mm

dew point/°C = 9.2 + (11.8-.9.2) x 30/40 = 11.15

According to the dew point and the temperature of the atmosphere, the relative humidity was 39.9%. This value coincided with the value 40% obtained by Assman-type psychrometer.

1- ITEM

A EUDIOMETER.

2- PURPOSE

To investigate the combining volumes of oxygen and hydrogen in a reaction vessel.

3- INFORMATION SUBMITTED BY

Kyoto Municipal Science Center for Youth, Kyoto 612, Japan.

4- LINE DRAWING OF PROTOTYPE

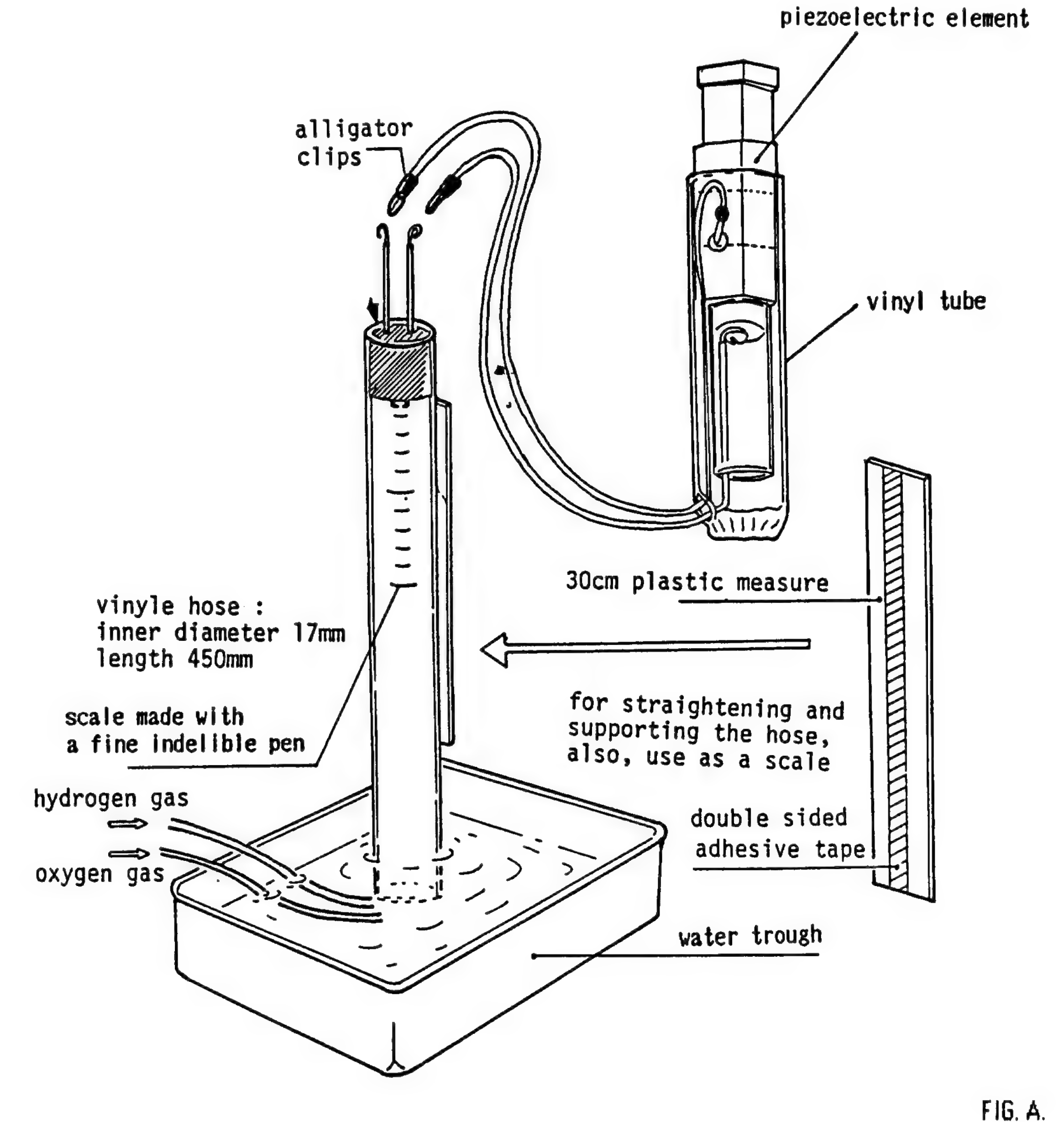


FIG. A.

5- TOOLS AND MATERIALS

(TOOLS)
Diagonal Cutting Nippers.
Side Cutting Pliers.
Long-nosed Pliers.
Scissors.
Electrical Soldering Iron.
Spirit Lamp.

(MATERIALS)
Clear Acrylic Tube (dia. 17mm. 50cm in length).
Vinyl Tube (dia. 13mm. 9cm in length)
Vinyl Tube (dia. 9mm. 6cm in length)
Vinyl Tube (dia. 1mm. 4cm in length)
Stainless Steel Wire (dia. 1mm)
Electrical Insulated Twin Cable.
Rubber Stopper (Size 3).........1
Piezoelectric Element (ML 28).........1
Screw (dia. 1.8mm).........1
Alligator Clip.........2

6- CONSTRUCTION DETAILS

See page 3.

6- CONSTRUCTION DETAILS (Continued)

A 50cm length of vinyl tube is used as a reaction vessel with a spark plug on its top, as shown in Fig. 1.

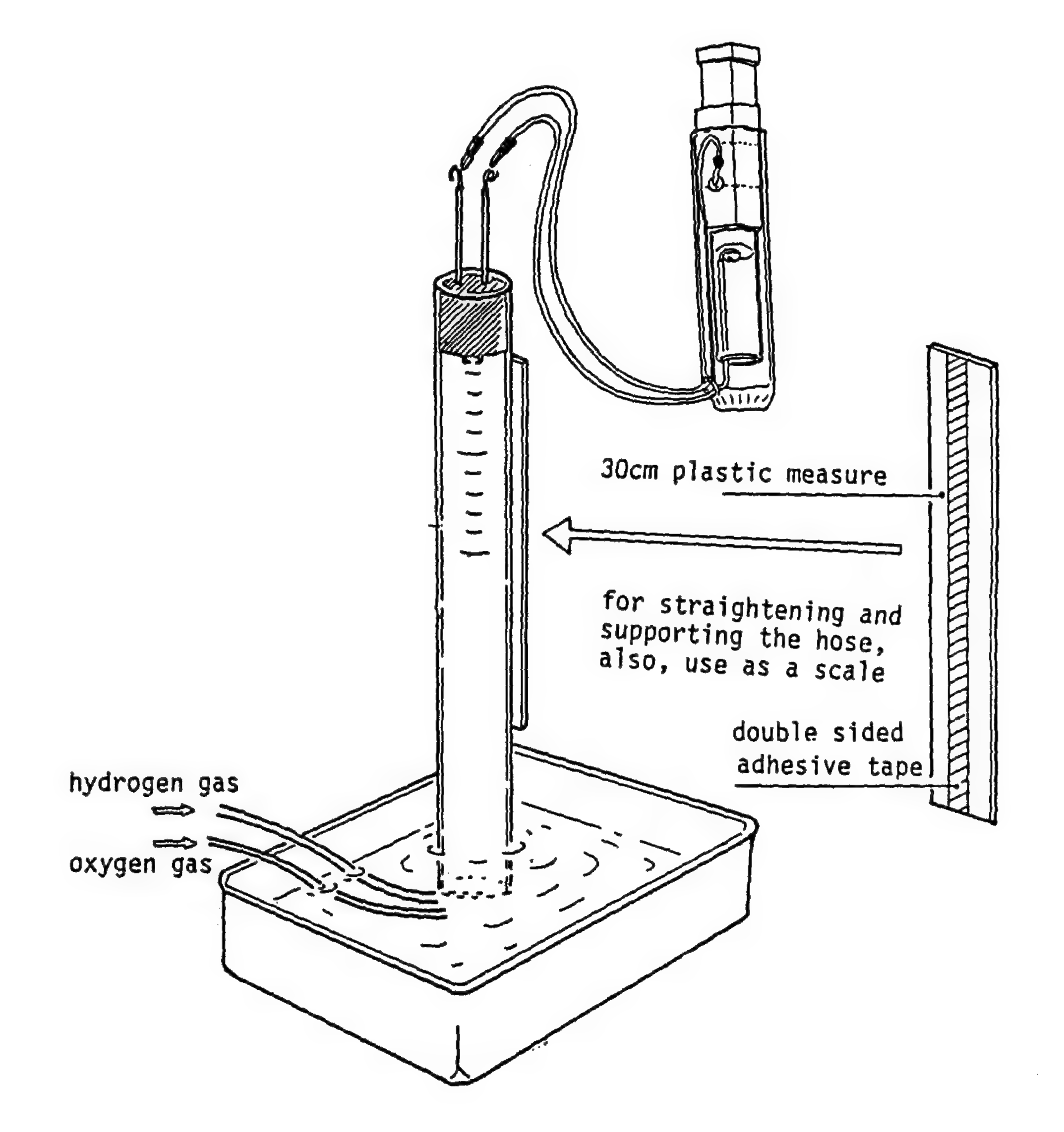


Fig. 1.

6- CONSTRUCTION DETAILS (Continued)

The spark plug is made by inserting two stainless wires into a rubber stopper and shaping their ends as in Fig. 2. in order to get sparks easily. The size of the rubber stopper should be chosen as to fit the tube but not to fly out when the mixed gas explodes.

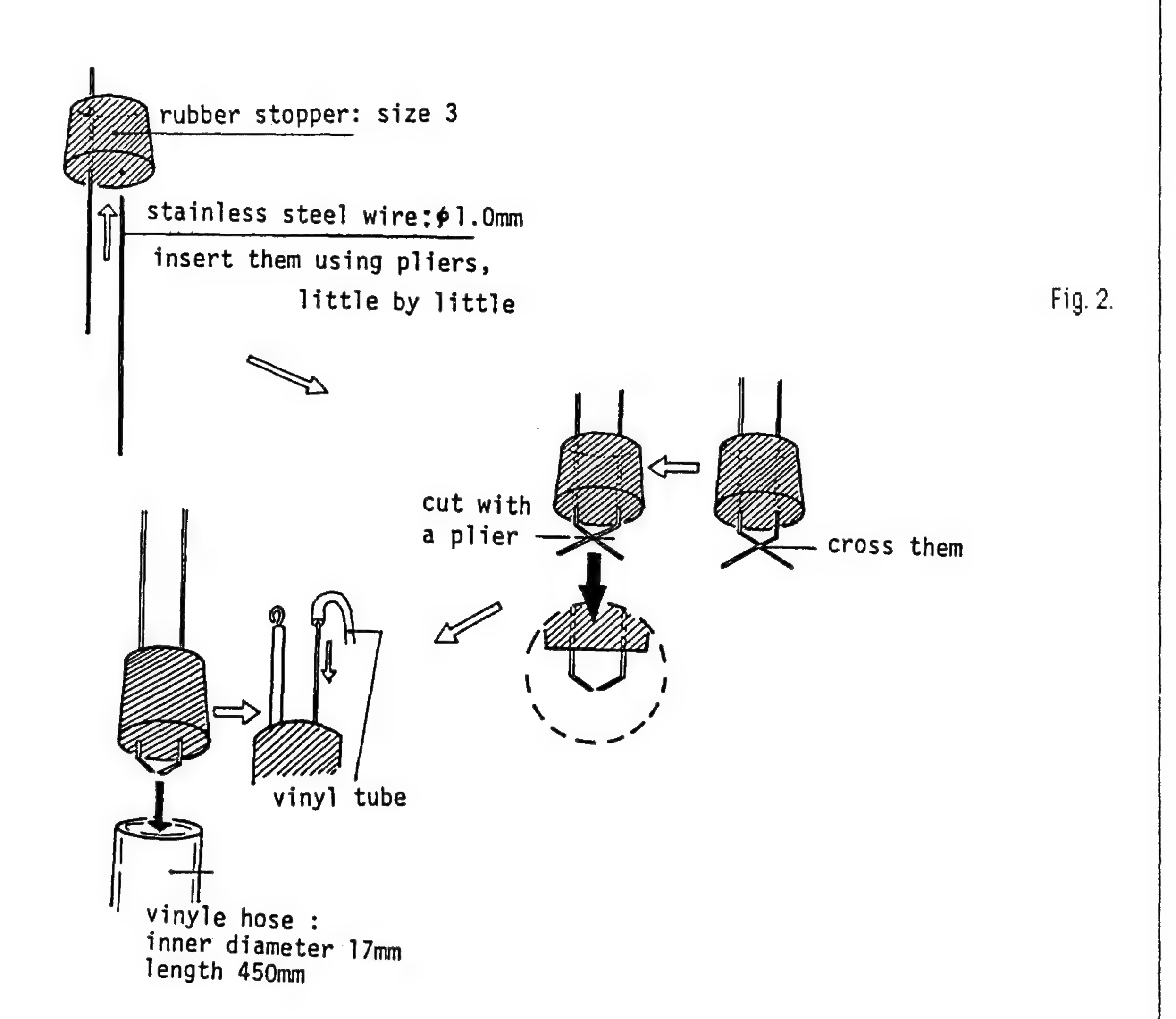


Fig. 2.

As the igniter a piezoelectric element of a cigarette lighter (12000V.30000 times ignition possible) is suitable. (See Fig. 3).

Connect insulated electrical cable to the elements by soldering, or by a screw, as the leads to the spark plug (as shown in Fig. 3.).

6- CONSTRUCTION DETAILS (Continued)

Attach a vinyl tube of 60mm in length to the bottom of the element as the support. Consequently, the lead from the bottom terminal goes through the support. (See Fig. 3).

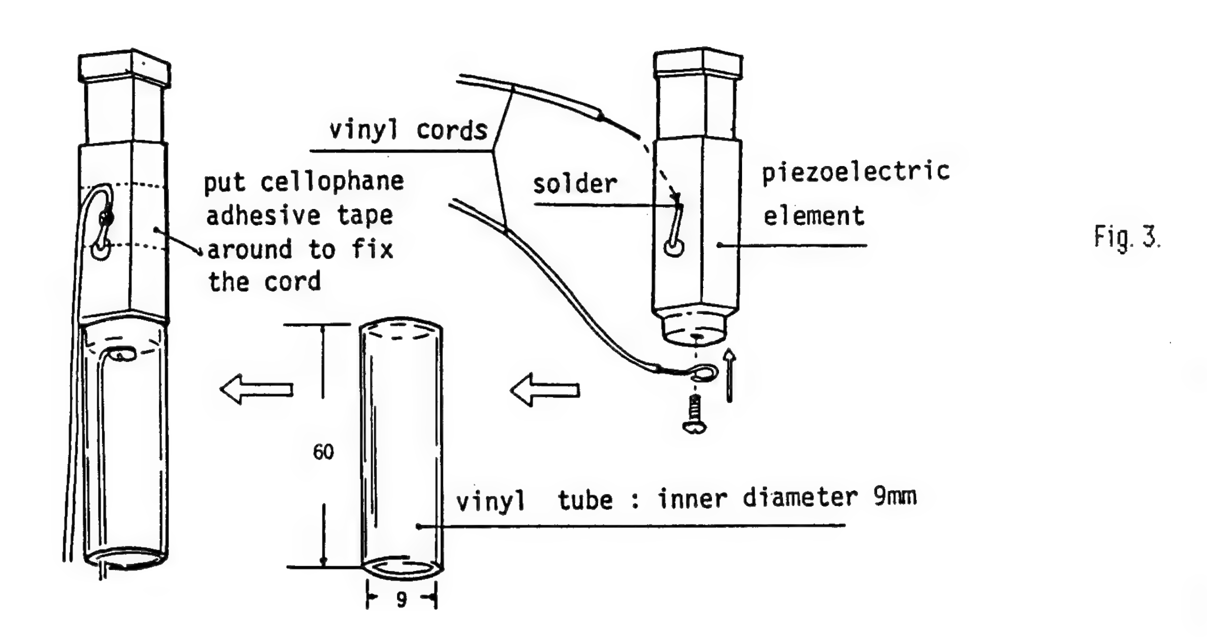


Fig. 3.

Make the case for the piezoelectric element using vinyl tube of approx. 90mm in length which will be convenient to handle.
Soften one edge of the tube by heating, close it with pliers, and make a hole for the leads at the corner. (See Fig. 4).

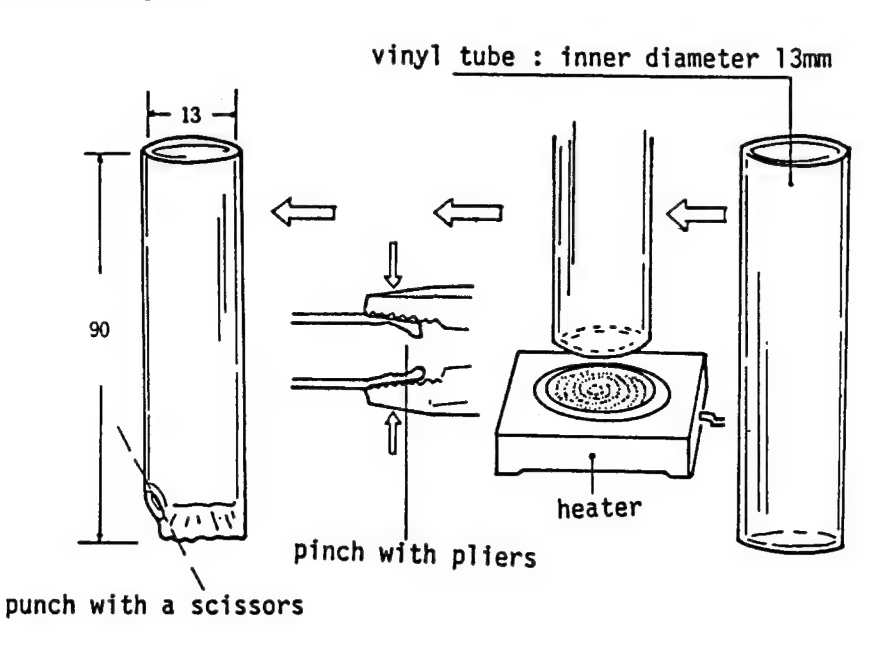


Fig. 4.

7- METHOD OF USE

The igniter is handled by holding it in one hand and pushing down its head with the thumb. The general view of the igniter is shown in Fig. A.

(1) Pour water in the trough to 80% of its capacity.

(2) Stand the reaction tube filled with water in the trough, and fix it with a ring stand. The lower edge of the tube should be kept 2 - 3 cm high from the bottom of the trough.

(3) Send hydrogen and oxygen from the bottom mouth of the tube, successively.

(4) Measure the volumes of hydrogen and oxygen. Keep the volume constant in order to get better results.

(5) Connect the igniter to the spark plug on the top of the reaction tube. The surface of the rubber stopper on the top of the tube must be wiped to make a spark.

(6) Fire!

As very strong explosions will occur(when the mixed gas consists of 1:2 mixture of oxygen and hydrogen), the reaction tube must be fixed firmly not to fly out. The volume of the mixed gas should be under 30% of the tube's volume, so that the gas does not blow off from the bottom of the tube.

(7) Measure the volume of the remaining gas.

(8) Send oxygen gas of a half volume of the remaining gas into the tube and fire again.

If the mixed gas explodes the remaining gas should be hydrogen, and if no explosion occurs it should be oxygen. Calculate the volume ratio of reacted gases based on the difference between the volumes before and after the explosion.

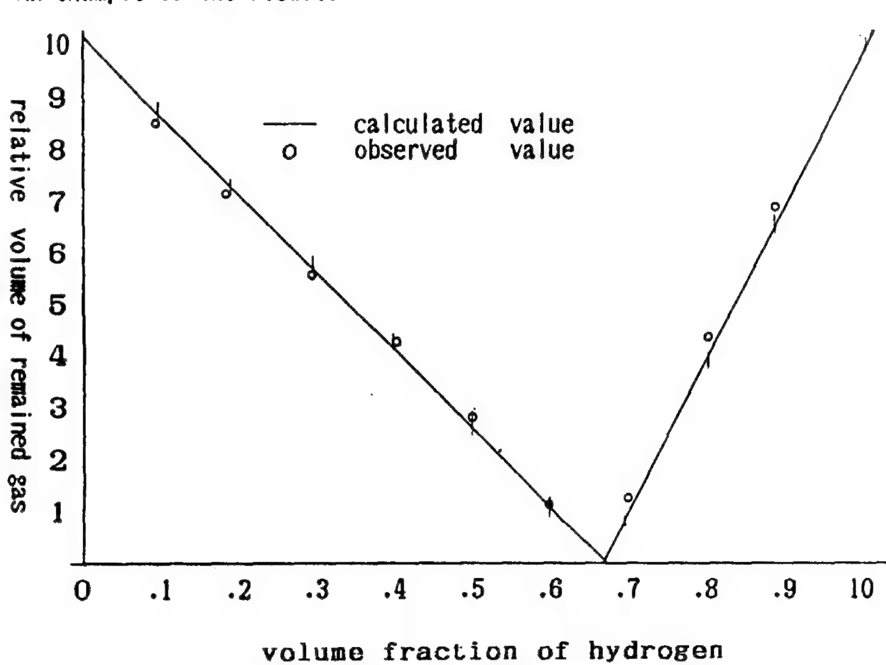
(9) Repeat the steps from (2) to (8) with gases in different volume ratios.



7- METHOD OF USE (Continued)



An example of the results



Note: Care should be taken when carrying out experiments involving explosions of gases. Eye and face protection, such as goggles and a safety screen, should be used.



1- ITEM

OXIDATION AND REDUCTION APPARATUS.

2- PURPOSE

To demonstrate the oxidation and reduction of copper by oxygen (atmospheric) and hydrogen.

3- INFORMATION SUBMITTED BY

Kyoto Municipal Science Centre for Youth, Kyoto 612, Japan.

4- LINE DRAWING OF PROTOTYPE

FIG. A.

5- TOOLS AND MATERIALS

(TOOLS)
Long-nosed Pliers.
Wood Saw.
Hammer.

(MATERIALS)

Test Tube (30mm dia. x 20cm).................................. 1.
Rubber Stopper Size 9.................................. 1.
Soldering Iron Heater with leads,
(Flat-type, 60 watt).................................. 1.
Copper Wire (dia. 2mm).................................. 2.
Plywood Sheet (70mm x 70mm x 5mm).................................. 1.
Alligator clips.................................. 2.
Copper Wire, Fine.
Refractory Tubes (insulators)
Vinyl friction tape (self-sealing)
Mains cable with switch and plug.
Nail

6- CONSTRUCTION DETAILS

(1) Insert two lengths of copper wire of dia. 2mm into a rubber stopper of size 9 to support the heater and to supply it with electricity. Using pliers bend their end parts of 30-40mm in length to make terminals. See Fig. 1.

(2) Tie together the heating elements and the covering iron plates of an electric soldering-iron (60W.) with fine copper wires as shown in Fig. 1.

6- CONSTRUCTION DETAILS (Continued)

(3) Cover the leads with refractory tubes and wind a friction tape around the leads and supports at appropriate positions. Wind the bare ends of the leads around each support. (See Fig. 1).

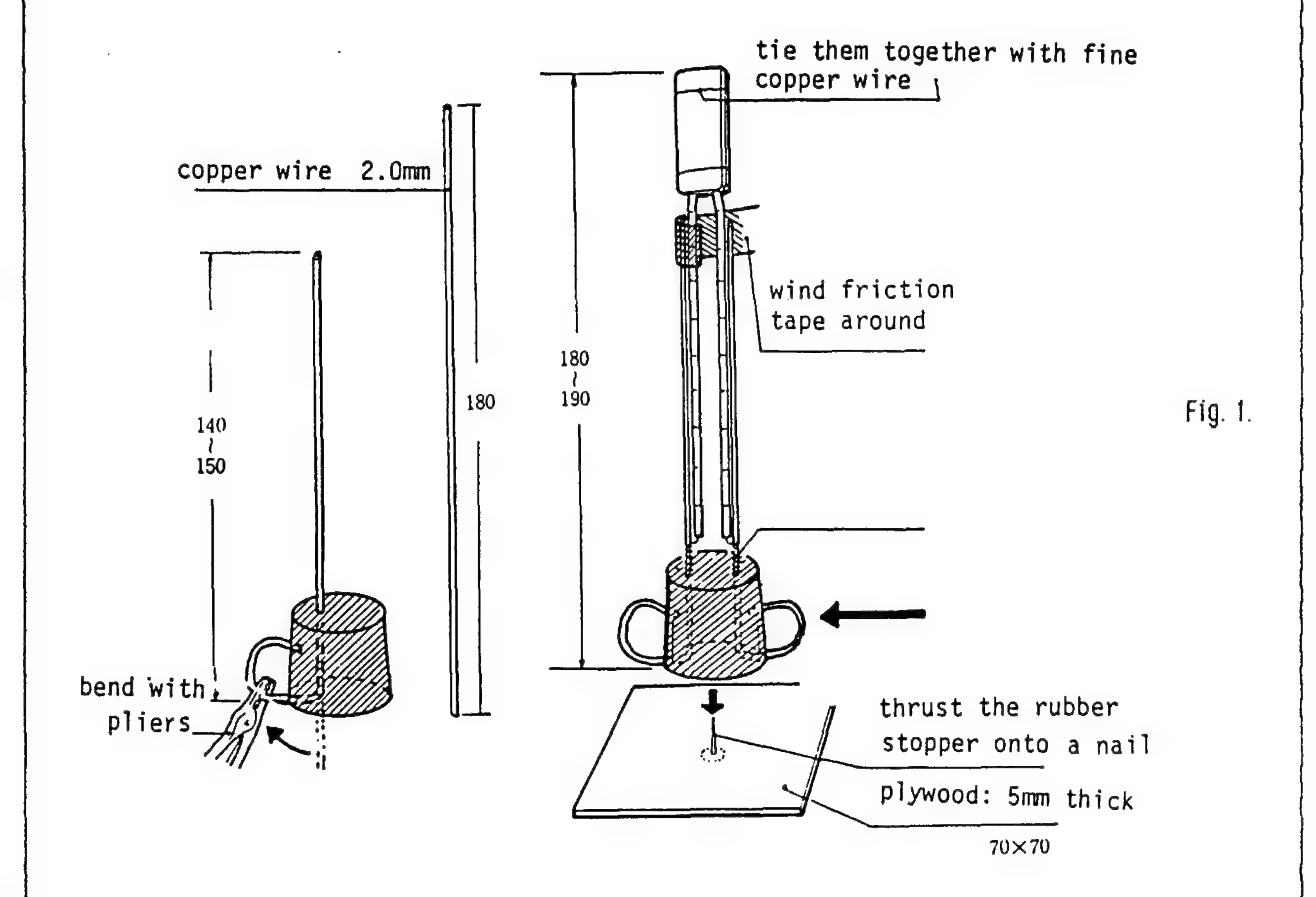


Fig. 1.

(4) Push the rubber stopper onto the nail which is thrust upward through the center of the base plate of plywood of 5mm thick.

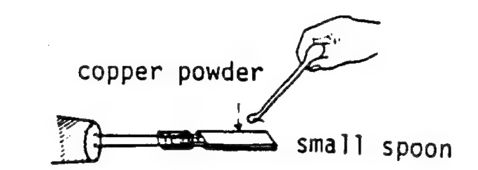
(5) Connect a cord with a plug and a switch to the terminals of the heater by alligator clips and insert the arrangement into the test tube as shown in Fig. A.

7- METHOD OF USE

The oxidation of copper with atmospheric oxygen and the reduction of its oxide with hydrogen can be observed with use of this equipment, constructed simply and manipulated easily, as shown in Fig. A.

According to the fact that the reduction temperature of oxidized copper is lower than the ignition temperature of hydrogen in the atmospheric air, the reduction goes without any accident caused by hydrogen.

(1) Lay the heater horizontally and put copper powder on it as shown below.



Experiment of copper oxidation

(2) Complete the heating circuit.
After about 10 seconds the copper powder will be oxidized to black cupric oxide, which has stuck to the surface of the iron cover of the heater. Then stand the heater on its base plate.

The oxide will be available for several repetitions of oxidation-reduction experiment.

(3) Put the test tube filled with hydrogen on the heater and shut off the heating current.

(4) The oxide will be reduced and change its colour into bright copper tone. Drops of water will be condensed on the inner surface of the test tube. This indicates the combination of the hydrogen gas and oxygen from the oxide.

1- ITEM

AIR COLUMN RESONANCE.

2- PURPOSE

Resonance in air column and wavelength of sound.

3- INFORMATION SUBMITTED BY

Kyoto Municipal Science Center for Youth, Kyoto 612, Japan.

4- LINE DRAWING OF PROTOTYPE

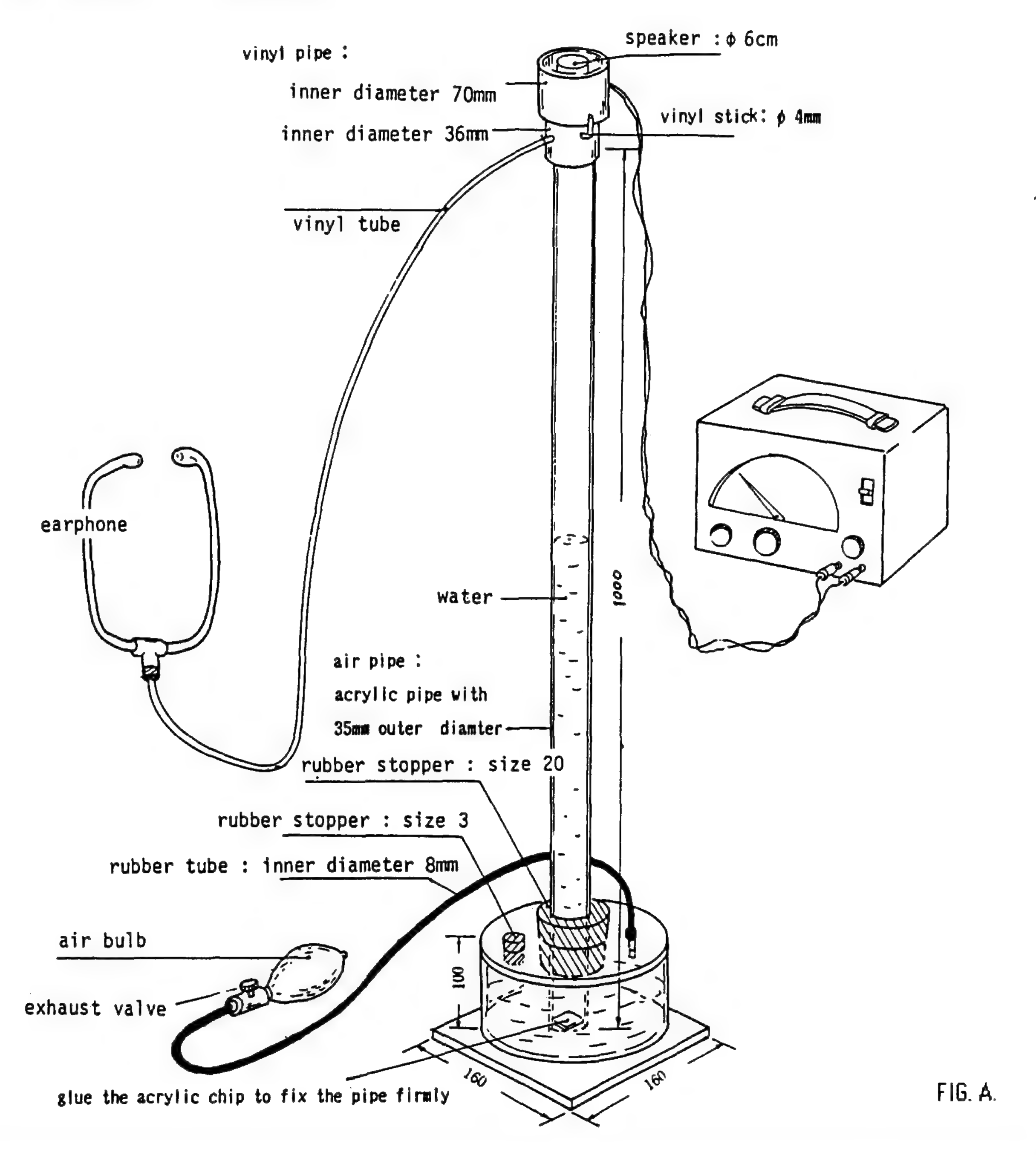


FIG. A.

5- TOOLS AND MATERIALS

(Tools)

Cutter for Acrylic Resin.	Drill Bit (dia. 6mm)
Hand-Saw.	Drill Bit (dia. 10mm)
Electric Hand Drill	Drill Bit (dia. 12mm)
Drill Bit (dia. 4mm)	Diagonal Cutting Nippers

(MATERIALS)

Clear Acrylic Tube (dia. 10mm outside: 4cm in length)
Clear Acrylic Tube (dia. 35mm outside: 1m in length)
Clear Acrylic Tube (dia. 130mm. outside: 10cm in length)
Vinyl Pipe (dia. 36mm inside: 5cm in length)
Vinyl Pipe (dia. 70mm inside: 5cm in length)
Vinyl Pipe (dia. 4mm outside: 6cm in length)
Rubber Tube (dia. 8mm inside: 60cm in length)
Vinyl Tube (dia. 6mm outside: 80cm in length)

Earphone
Air Bulb (for sphygmomanometer use)..1
Multi-Strand Insulated Electrical Wire
(vinyl insulated. 3m in length)..1
Radio Speaker (dia. 6cm)..1
Rubber Stopper (size 1)..1
Rubber Stoper (size 3)..1
Rubber Stopper (size 20)..1

6- CONSTRUCTION DETAILS

See page 3.

6- CONSTRUCTION DETAILS (Continued)

(OUTLINE)

As shown in Fig. 1. the main part of the equipment is the transparent acrylic pipe A (35mm outer diameter, 1.5mm thick. 100cm long) inserted deeply into the water tight tank.

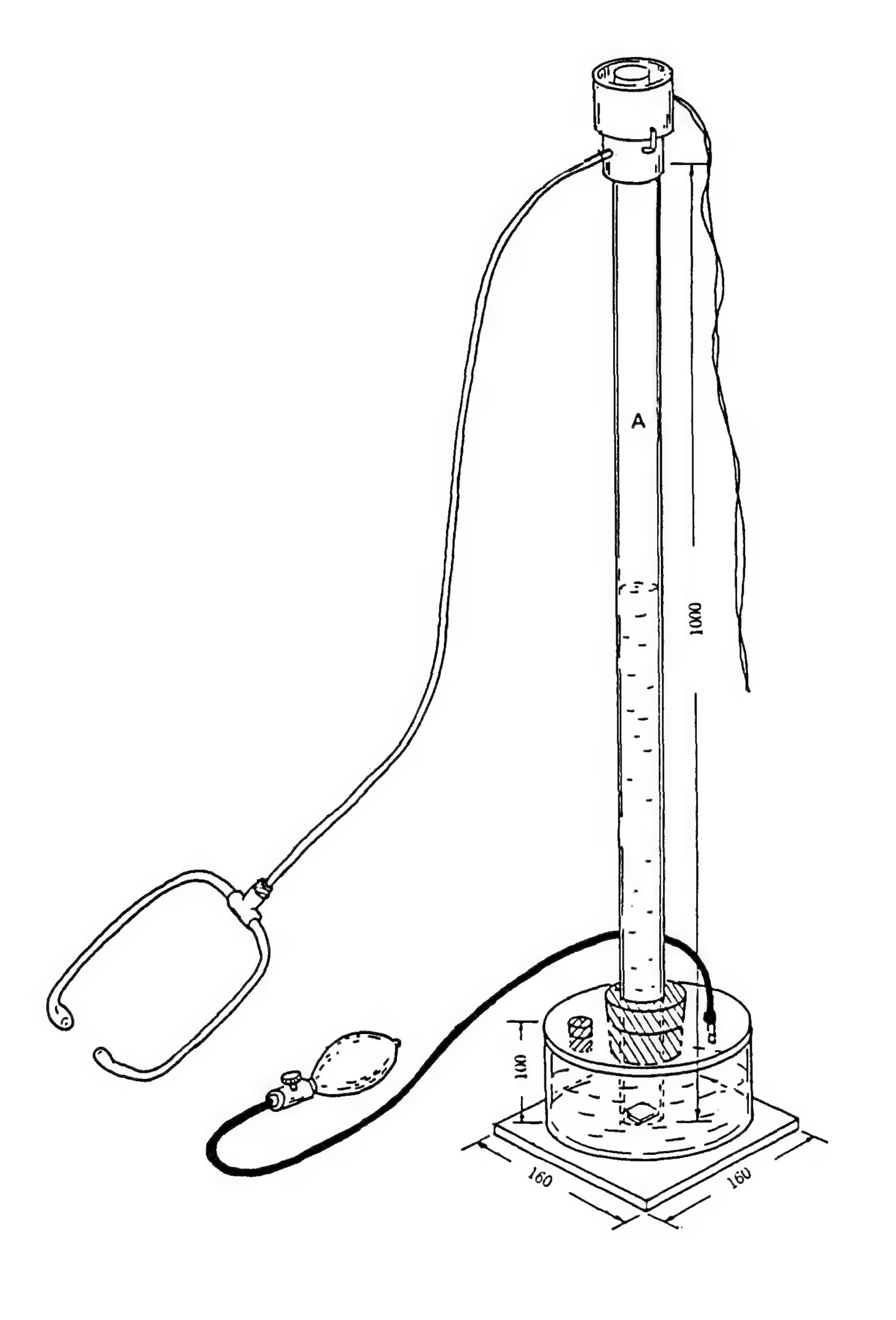
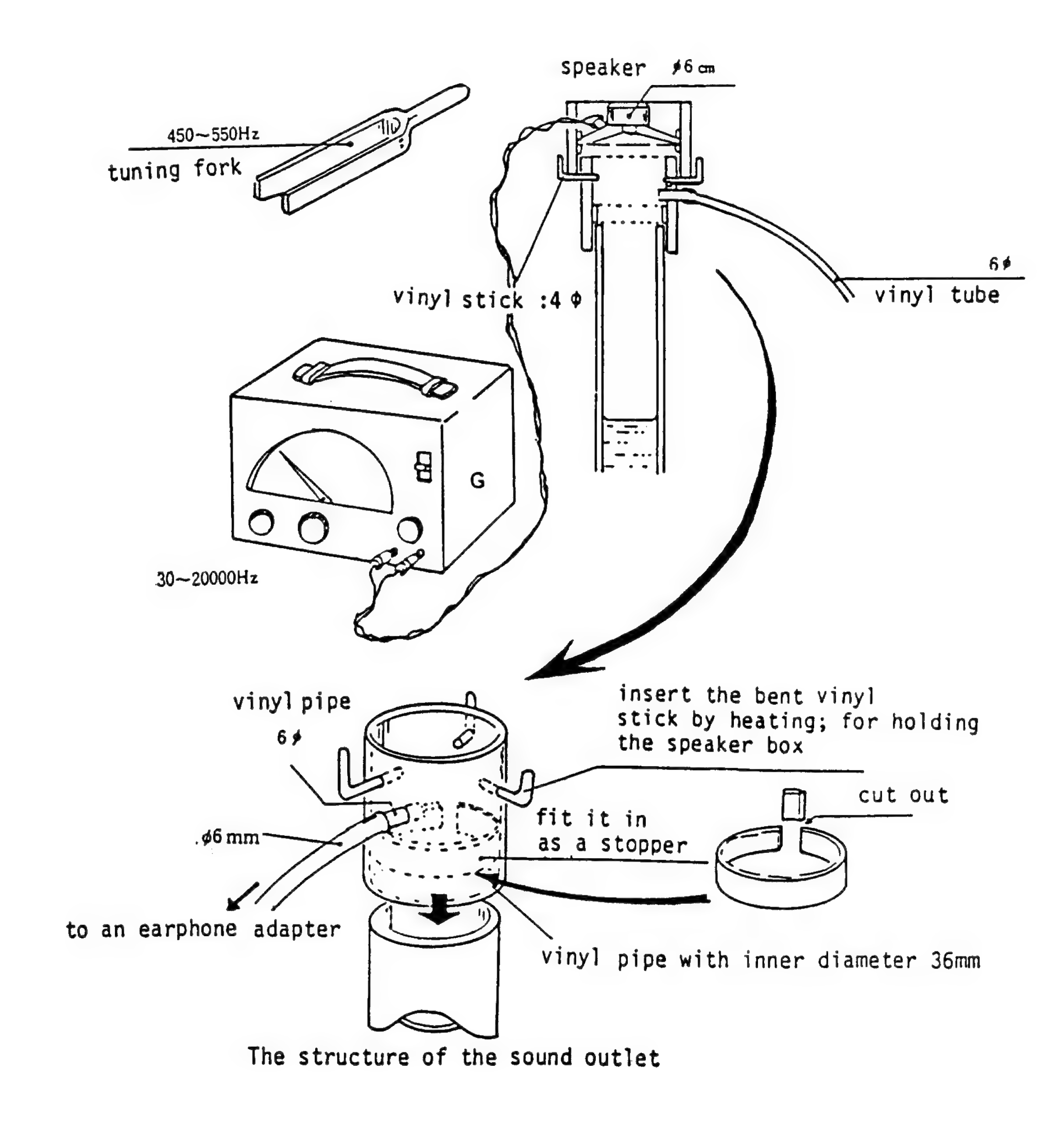


Fig. 1.

6- CONSTRUCTION DETAILS (Continued)

(DETAILS OF SOUND OUTLET)

As a sound source on the holder use either a tuning fork or a small radio's speaker connected to the low frequency oscillator, as shown in Fig. 2.

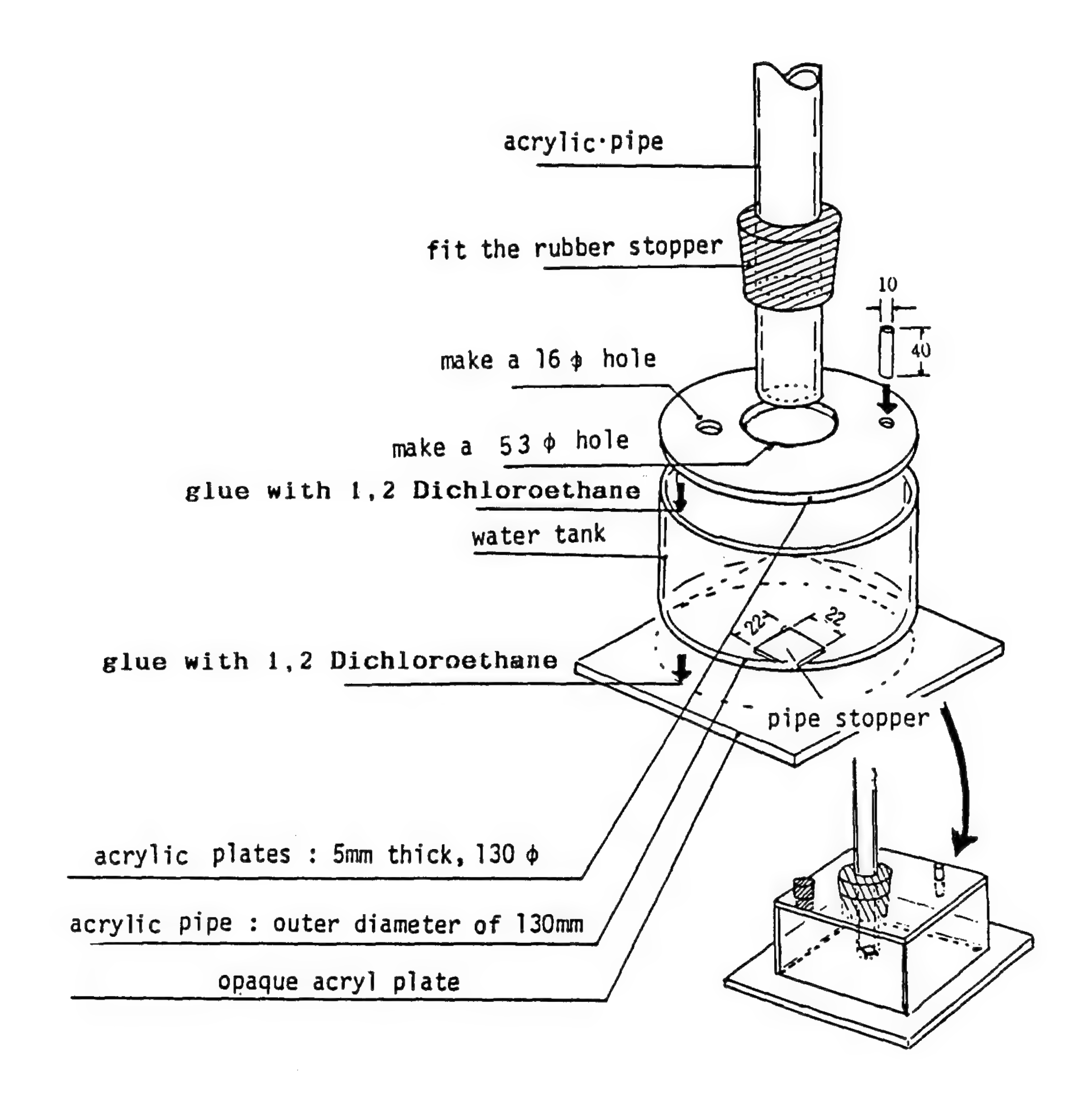


The structure of the sound outlet

Fig. 2.

0- CONSTRUCTION DETAILS (Continued)

(DETAILS OF WATER TANK)
How to set up the water holding part, as shown in Fig. 3.



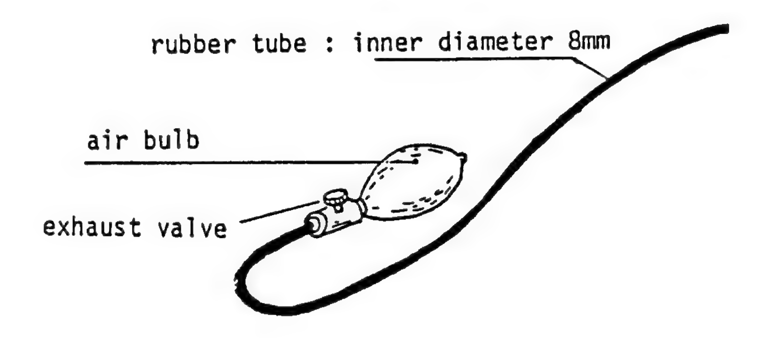
As an alternative the water tank could be rectangular.

Fig. 3.

6- CONSTRUCTION DETAILS (Continued)

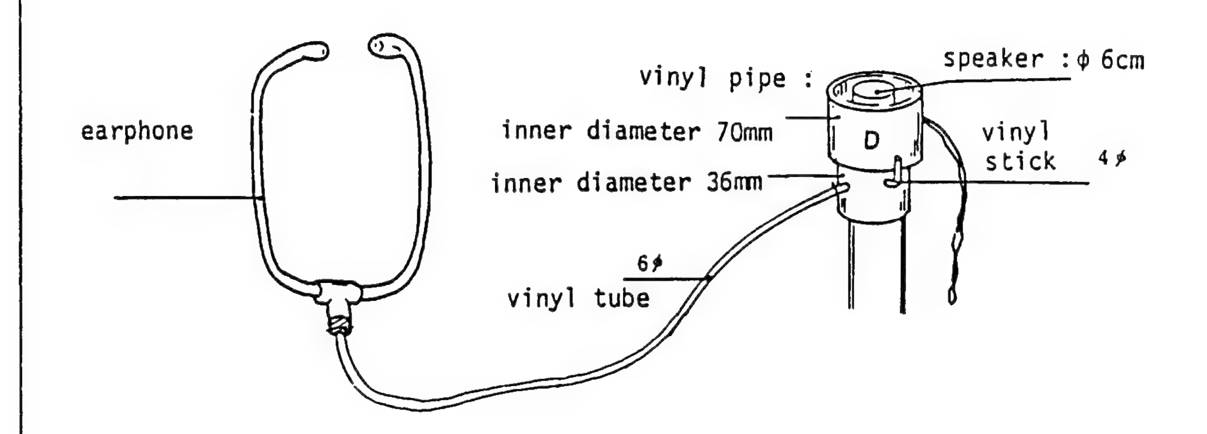
When sendng air from the air bulb, the water level in the pipe rises up, and when loosening the exhaust valve it falls down.

The speed of water rising and falling can be changed by the speed of compressing the air bulb and by the degrees of the valve opening respectively (below).



On the top of the pipe, there is a holder constructed of vinyl pipes including the sound outlet connected to an earphone by a vinyl tube.

This adapter can catch the vibrations of the air in the tube, thus allowing for a search of the resonance point acurately without being bothered by the surrounding noises, as is the case of a doctor's stethoscope (below).



7- METHOD OF USE

The equipment devised may be used for demonstration, but it is also designed for pupil use. It is able to change quickly and hold constantly the length of the air column. Only one hand need to be used for handling.

In addition, the earphone is attached so that when many groups have the same experiment in a class each group is not disturbed by noise from the others.

(1) Pour about 1000cm of water in the tank (80% of its capacity).

(2) Pump up the water level in the pipe to 5cm from the top.

(3) Put the speaker on the holder at the top of the pipe, and connect it to the low frequency oscillator.

(4) Operate the speaker at 440HZ.

(5) Adjust the volume of the earphone.

(6) Loosen the exhaust valve slowly to lower the water level and, as accurately as you can, search for the level which makes the strongest sound.
Mark a line indicating the water level on the side of the pipe.

(7) Continue the lowering of the water level, and you will find out another maximum of sound, then mark a line again in the same way as (6).

(8) Repeat the steps (6) to (7) on 880HZ.

(9) Do the same experiment, step (6) to (7) with a tuning fork instead of the speaker.

* Since the difference between water levels at (6) and (7) is a half of the wave length of sound from the speaker, if the frequencies used in (6) - (8) are accurately known, you can determine the wave length and the frequency of the sound from a tuning fork based on those results.

1- ITEM

AIR MOISTURE APPARATUS.

2- PURPOSE

To determine the amount of moisture in atmospheric air.

3- INFORMATION SUBMITTED BY

Kyoto Municipal Science Center for Youth, Kyoto 612, Japan.

4- LINE DRAWING OF PROTOTYPE

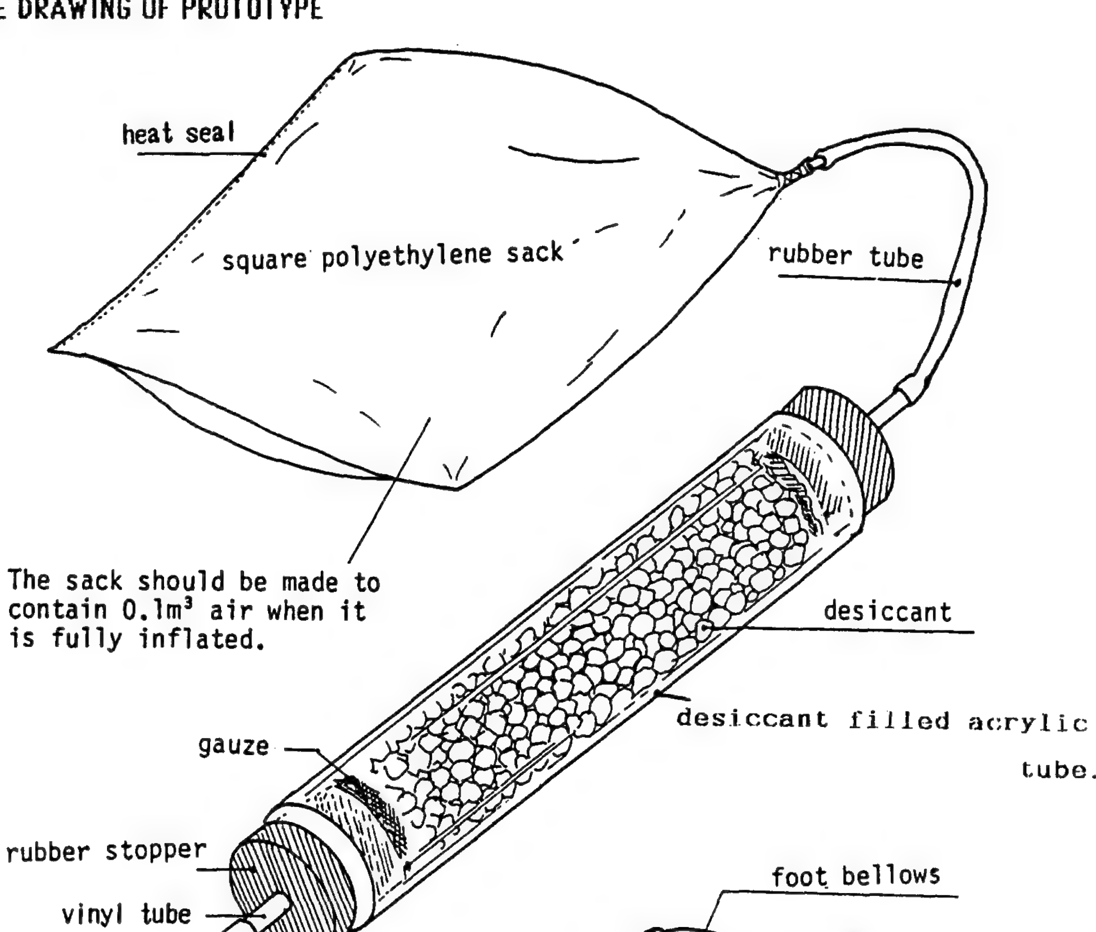


FIG. A.

5- TOOLS AND MATERIALS

(TOOLS)
Cutter for Plastics
Pliers
Cork Borer
Foot Bellows
Balance

(MATERIALS)
Acrylic Tube (dia. 30mm inside; 1mm thick; 110mm in length)
Vinyl Tube (dia. 6mm inside; 60mm in length)
Styrofoam Disc (dia. 30mm)
Gauze
Square polyethylene Sack (87cm x 97cm)
Adhesive Tape
Adhesive Paste (suitable for vinyl)
Calcium Chloride
Rubber Tube (dia. 7mm inside; 2mm in length)
Rubber Stopper (Size 11)..4

6- CONSTRUCTION DETAILS

(OUTLINE)
As shown in Fig. A. the foot bellows and polyethylene sack of a known volume are connected to either end of the desiccation tube whose weight has been measured beforehand. The air is sent by the bellows through the tube into the sack until it is filled. The weight of the tube increases by the weight of moisture in the air with which the sack is filled.

(DETAILS)
(1) Polyethylene sack
The maximum capacity of the sack is adjusted to be exactly $0.1m^3$ by the following procedures, (to simplify the calculation in the experiment): Attach a vinyl tube of 10mm in outer diameter to one of the corners of a sack of about 1 m in edge length, with adhesive or adhesive tape. (See Fig. 1.)

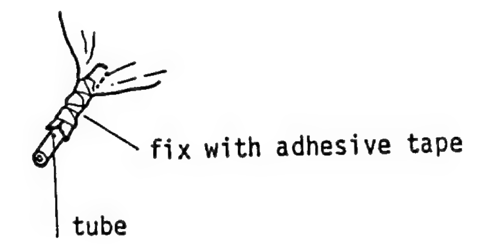


Fig. 1.

Seal the mouth of the sack by heating and check it for air-tightness. Inflate it fully and measure the maximum capacity by collecting the air from it over the water.

Fully inflate the sack again and fold it little by little at the adjacent two edges, and measure the volume of expelled air, until $0.1m^3$ remains in the sack. Heat seal the folded edges by using an electric iron or a soldering iron. Test again the airtightness of the sack.

(2) Desiccating tube

Cut an acrylic tubing of 1mm in thickness and 30mm in inner diameter to 110mm length. Make a styrofoam disk which is 30mm in diameter and 10mm in thickness and has a hole of 7mm in diameter at the center. Cover it with two sheets of gauze (see Fig. 2.), to filtrate spattered desiccant. Similarly make another disc for the other end.

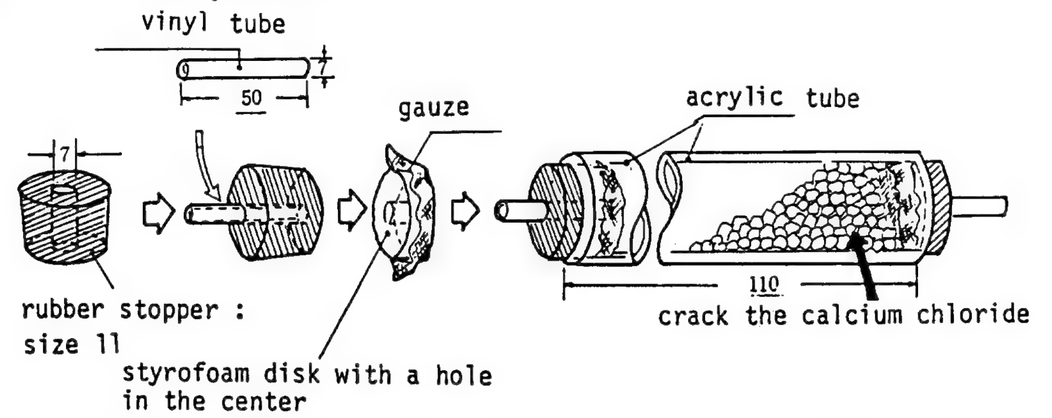


Fig. 2.

Crack fresh calcium chloride into pieces of soybean size. Parch them to dryness on a gas heater (see Fig. 3.) then put them into the tube. Hold them with the styrofoam disks, and close the tube with solid rubber stoppers at both ends. The weight of the tube will be about 100g. Between the rubber stopper and the styrofoam disk, make a space of 5mm in length. (During the experiment, the rubber stoppers are replaced with single-holed ones (as shown in Fig. 2.)

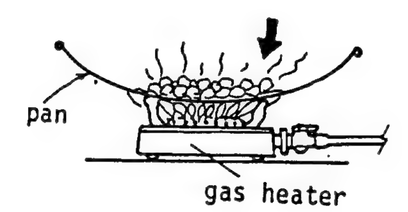


Fig. 3.

7- METHOD OF USE

On a rainy day, we feel damp and wonder how much moisture is in the air. This equipment allows us to measure easily the weight of the moisture in a given amount of air.

(1) Weigh the sealed desiccation tube to 0.01g.

(2) Replace the rubber stoppers of the sealed desiccation tube with the single-holed ones. Connect one of the single-holed rubber stopper to the polyethlene sack, from which the air has been expelled as much as possible, and the other to the foot bellows. (See Fig. 4).
The foot bellows should be put on a dry plastic sheet, to avoid the moisture from the bare floor.

(3) Using the bellows pass air through the tube to the sack, until it is filled with the air. The rate of sending air should not be too fast; thirty times of full blowing per 1 min may be an appropriate rate.

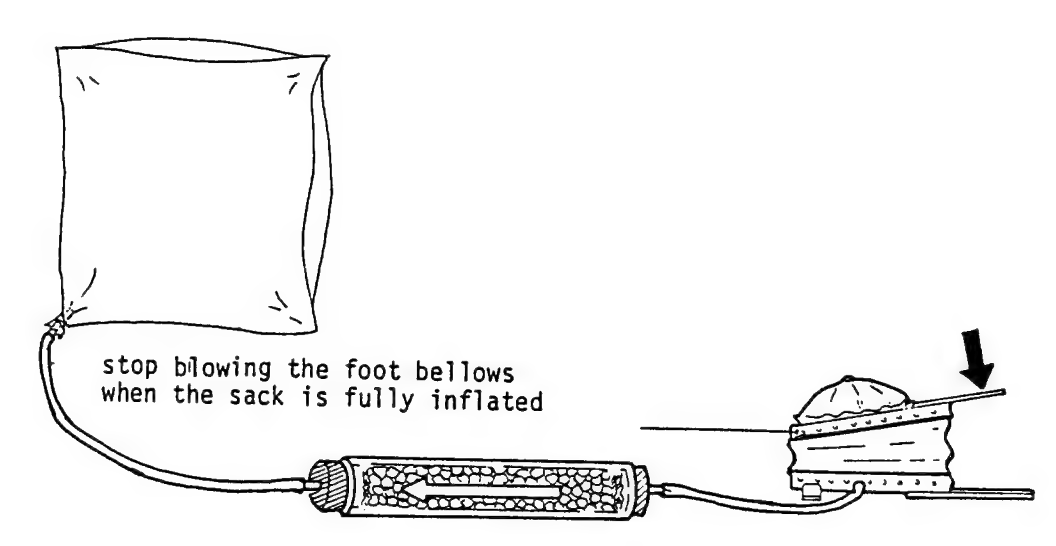


Fig. 4.

(4) Replace again the solid rubber stoppers in the tube, to seal it, and weigh it to get the weight increase by absorption of moisture.

(5) The calcium chloride can be used repeatedly by parching. Take care of hydrochloric acid evaporating from the heated calcium chloride.

7- METHOD OF USE (Continued)

(EXAMPLES OF THE RESULT)

Some of the results of pupil's experiment with use of this equipment are as follows:

Class	A	B	C
Date	June 24	Oct. 27	Jan. 29
Weather	Cloudy	Cloudy	Cloudy
Temp. °C	25.0	20.8	16.5
R.H..%	64	50	41
Moisture in the air. g/m^3 :			
calc. from R.H	1.5	0.9	0.6
obs. values by groups	1.3	1.0	0.6
	1.5	1.0	0.6
	1.4	1.0	0.6
	1.5	1.0	0.7
	1.5	1.0	0.6
	1.5	1.0	0.6
	1.5	1.0	0.7
	1.6	0.9	0.8
	1.4	0.8	0.6

1- ITEM

ELECTROLYSIS OF WATER.

2- PURPOSE

To obtain Oxygen and Hydrogen by the Electrolysis of Water.

3- INFORMATION SUBMITTED BY

Kyoto Municipal Science Centre for Youth, Kyoto 612, Japan.

4- LINE DRAWING OF PROTOTYPE

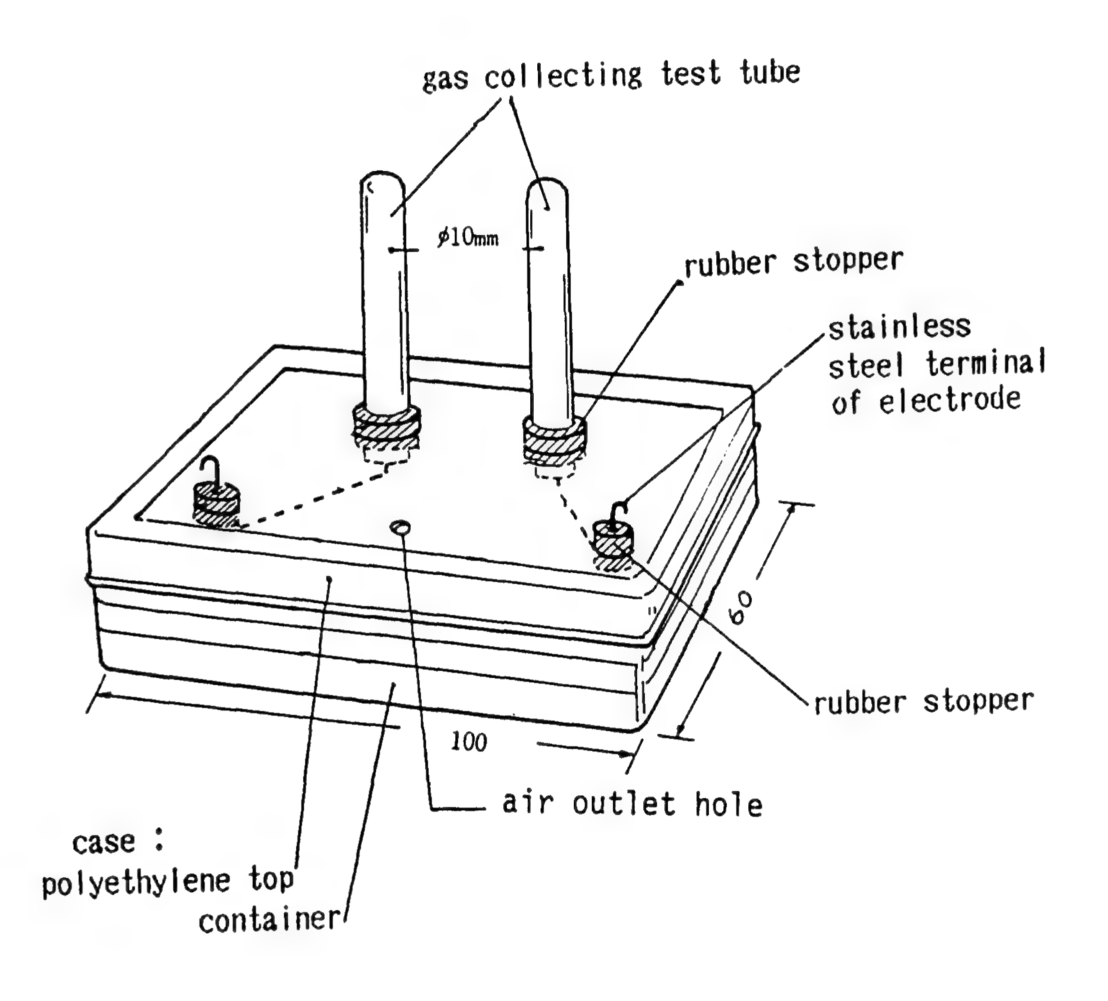


FIG. A.

5- TOOLS AND MATERIALS

(TOOLS)
Taper-nosed Pliers
Spirit Lamp
Cork Borer
Hacksaw
Aluminium tube (dia. 16mm. outside: 10cm in length)
Aluminium tube (dia. 10mm. outside: 7cm in length)
Iron Rod (dia. 4mm. outside: 10cm in length)
Nail (dia. 4mm. outside: 7cm in length)
Electric Hand Drill.
Drill Bit (dia. 2mm)

(MATERIALS)
18-8 Stainless Wire (dia. 0.8mm. 50cm in length)
Vinyl Tube (dia. 1.0mm. 10cm in length)

Clear Plastic Case with polyethylene top 60mm x 100mm x 25mm........1
Rubber Stopper (Size 2)........2
Rubber Stopper (Size 0C)........2
Test Tube (dia. 10mm)........2

6- CONSTRUCTION DETAILS

(1) Prepare metallic tubes (dia. 16mm and dia. 10mm) and rod (dia. 2mm). The tube of 16mm diameter can be obtained by cutting off the tip of a felt pen with a hacksaw.

(2) Heat the tube or rod with a spirit lamp and make holes as shown in Fig. 1.

6- CONSTRUCTION DETAILS (Continued)



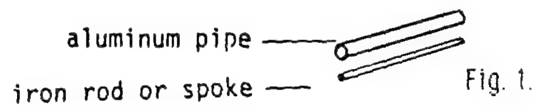
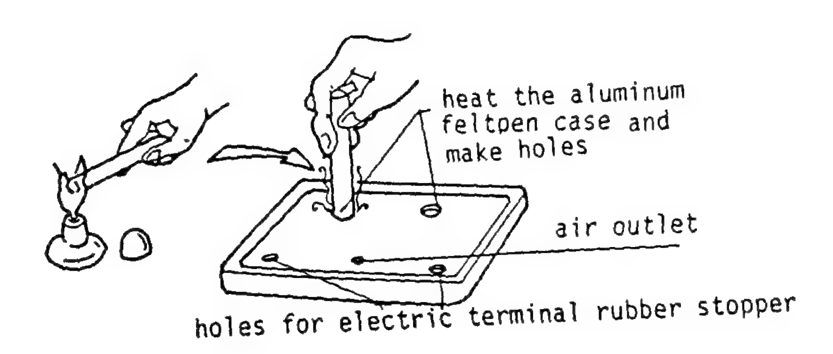


Fig. 1.



The bigger holes are used to connect the collecting test tubes, the smallest as the path of air, and the other two to fix the electrodes...

(3) Make a hole through each of the two rubber stoppers (size 2), and put a collecting text tube (dia. 10mm) into it.

(4) Since inside dimensions of test tubes may be different, check before using by pouring 3ml of water into each test tube; if the water levels show.the same height these two tubes can be used for this apparatus.

(5) Make a coil of twenty turns in the middle of the length of stainless steel wire by coiling it around a nail of dia. 4mm (See fig. 2.)

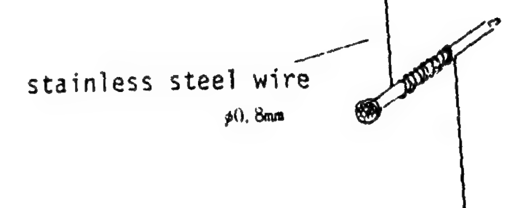


Fig. 2.

6- CONSTRUCTION DETAILS (Continued)

Cut the coil into equal parts of L-shape. Cover the straight parts with vinyl tubes and leave the coils bare as the electrods (See Fig. 3.).

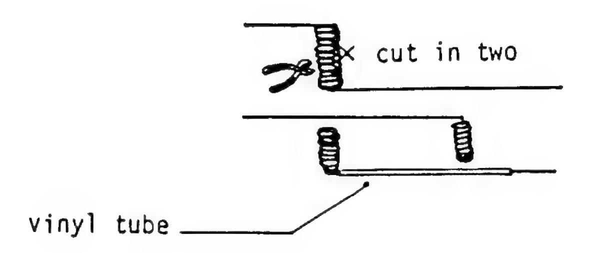


Fig. 3.

Bend up the tail of the L-shaped wire and put the end into a one-holed rubber stopper of size OC (See fig. 4.).

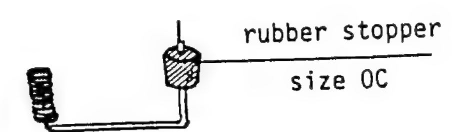


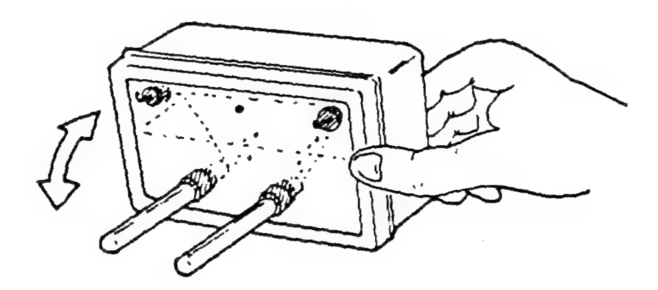
Fig. 4.

(6) If you use nichrome or stainless wire, which is sensitive to magnetism, sometimes the solution around the positive electrode may change colour and become red.

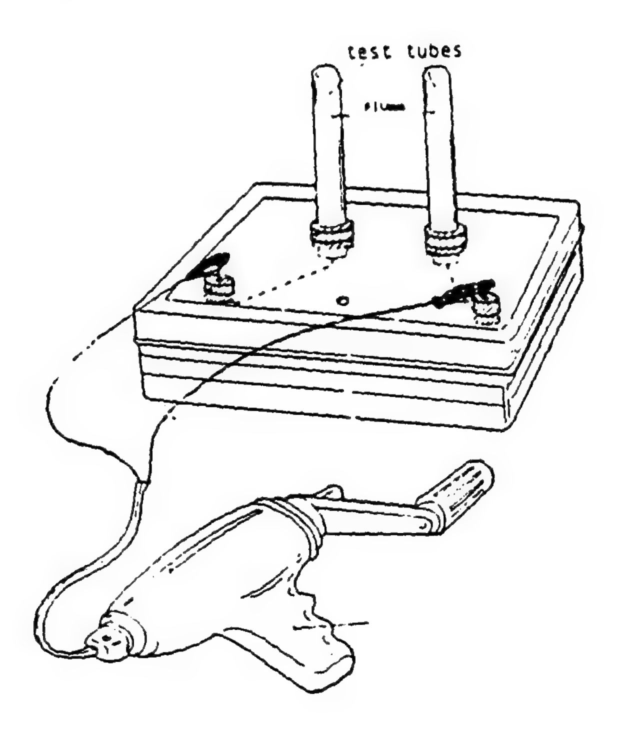
(7) Assemble the apparatus as shown in Fig. A.

7- METHOD OF USE

(1) Fill the case half with the liquid (50ml). Set it on edge with air hole higher than the level of the liquid, and the liquid will flow into the test tubes. When the tubes are filled, turn the case back.



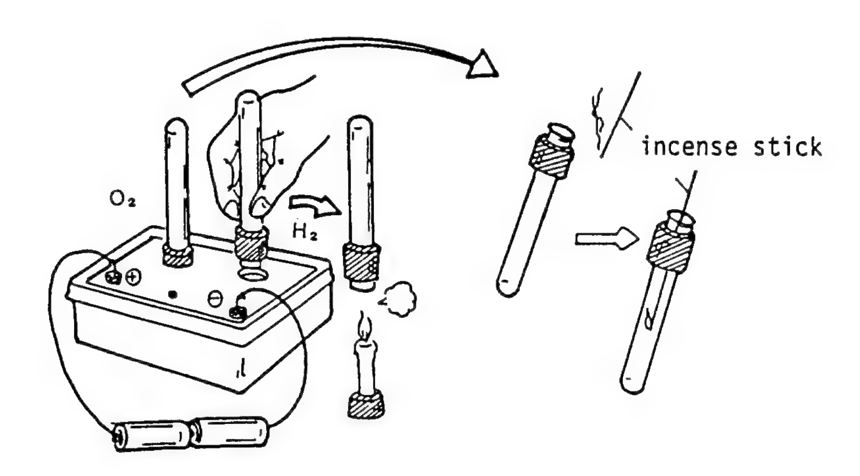
(2) Generate electricity using a hand driven generator or by connecting the lead wires from a dry cell to the terminals.



7- METHOD OF USE (Continued)

(3) Observe that one of the test tubes contains twice as much gas as the other.

(4) When the test tube at the side of negative pole is filled with gas, remove it from the case and bring it close to a candle flame (after wiping the mouth of the test tube with paper), as indicated below.



(5) When oxygen is stored in the test tube, take it out, wipe away any water around its mouth, and then put an ignited incense stick into the tube as indicated above.

1- ITEM

POLARIZER.

2- PURPOSE

To observe thin sections of rock under polarised light.

3- INFORMATION SUBMITTED BY

Kyoto Municipal Science Center for Youth, Kyoto 612, Japan.

4- LINE DRAWING OF PROTOTYPE

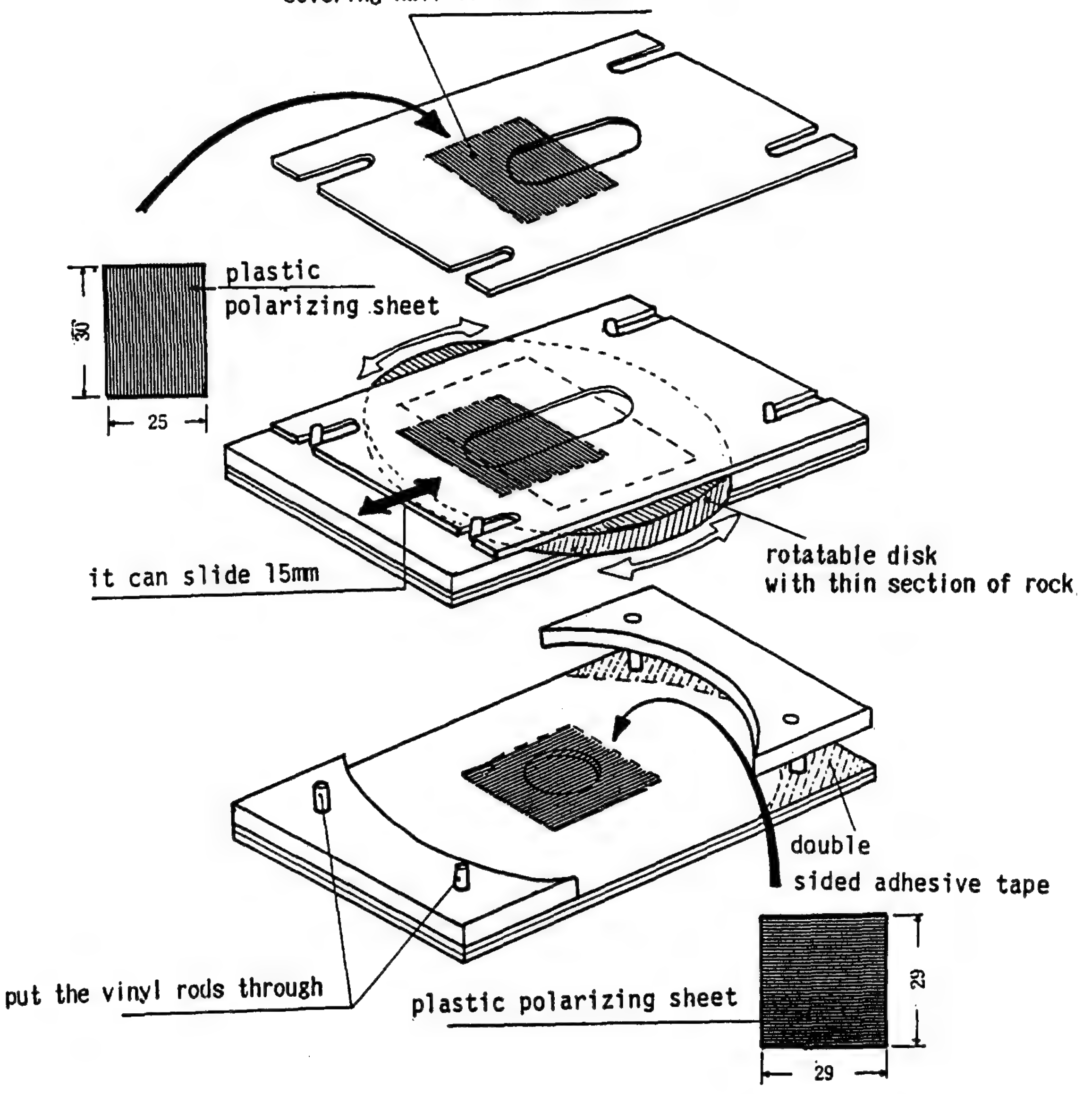


FIG. A.

5- TOOLS AND MATERIALS

(TOOLS)
Cutter for Plastics
Cutter for Plastics (for circles)
File (for glass cutting)
Round-File
Electric Hand Drill
Drill Bit (dia. 3mm)
Diagonal Cutting Nippers
Shears

(MATERIALS)
Acrylic Sheet (108mm x 75mm x 3mm)....................1
Vinyl Sheet (90mm x 60mm x 1mm)....................1
Vinyl Sheet (105mm x 60mm x 1mm)....................2
Chloroethylene Rod (dia. 3mm. 45mm in length)
Plastic Polarizing Sheet (29mm x 29mm)....................1
Plastic Polarizing Sheet (25mm x 29mm)....................1
Double Sided Adhesive Tape
Adhesive Paste (suitable for vinyl plates)

6- CONSTRUCTION DETAILS

This equipment is composed of a base plate to fix the one polarizing sheet, a rotable disk, and a top plate to fix the other sheet, as shown in Fig. A.

(1) Cut two vinyl plates of 1mm in thickness to 105 x 60mm in size. Make a hole of 16mm in diameter at the center of one of them. Cut out a window of 30mm square from the center of the other plate. (See Fig. 1).

Affix the two plates with double sided adhesive tape or by glueing them with a suitable adhesive for vinyl resin.

6- CONSTRUCTION DETAILS (Continued)

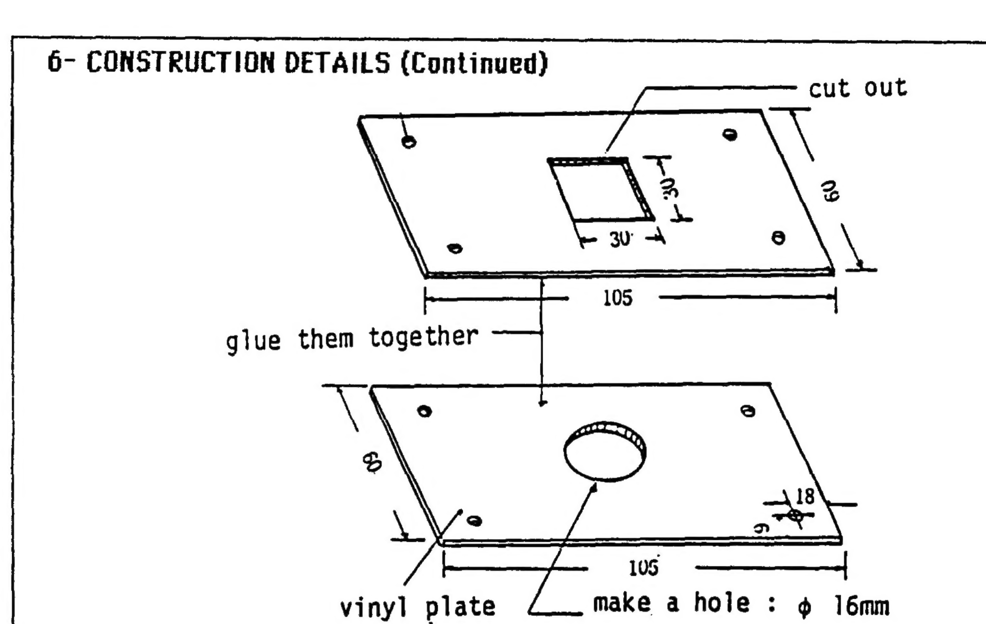


Fig. 1.

(2) Make the top plate, as shown in fig. 2. The slots can be made by drilling holes first then cutting out the linear strips.

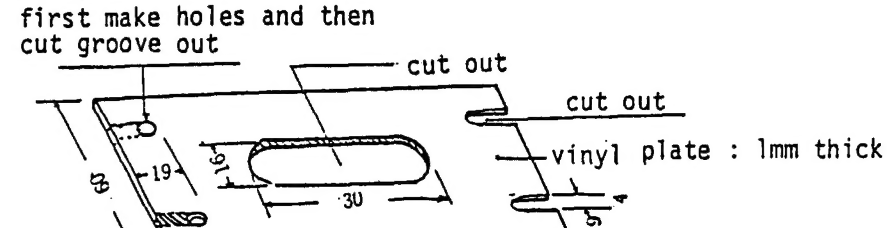


Fig. 2.

(3) Cut out a piece of 3mm acrylic sheet to the sizes shown. Using a thin saw blade cut out the 70mm dia. disc from the center of the plate. From the center of the disc cut out a rectangular window of size 29 x 48mm. (See Fig. 3).

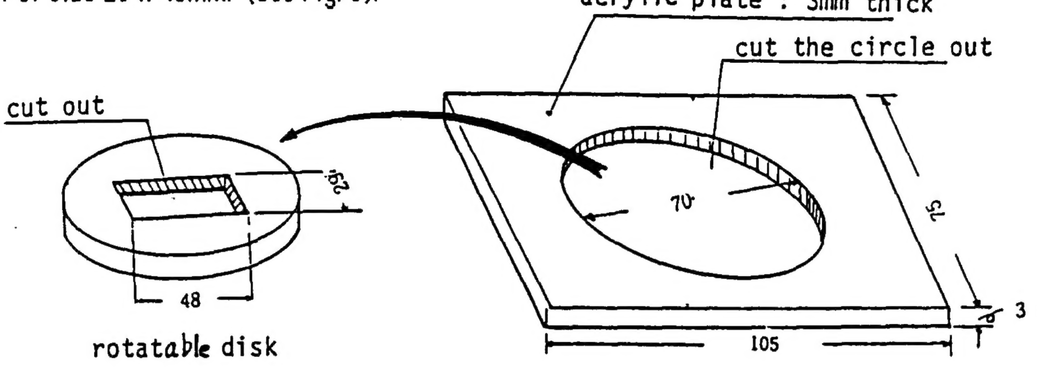


Fig. 3.

(4) As shown in Fig. 4. cut off both sides of the acrylic plate to make the guides for the rotating disc.

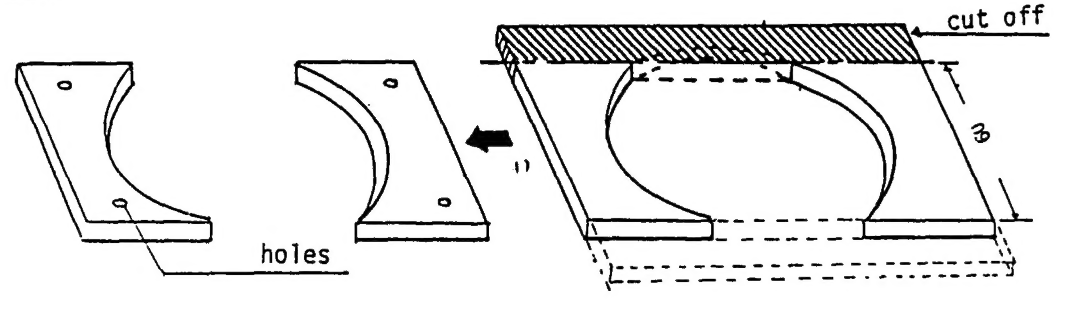


Fig. 4.

6- CONSTRUCTION DETAILS (Continued)

Assemble the base plate, the rotatable disk, and its guiding frames, and fix the frames to the base with double sided adhesive tape so that the disk rotates smoothly between them.

(5) Put the top plate exactly on the guiding frames affixed to the base, and make four holes of 3mm in diameter as indicated in Fig. 4. Remove the top plate. Insert a 10mm length of vinyl rod into each of the holes, and fix with adhesive.

(6) Overlap two pieces of polarizing sheet at the relative position that gives them the minimum transparency. Holding the position, affix them to the top and the base plates respectively using double-sided adhesive tape. Be careful not to cover the window with a tape. (See Fig. 5).

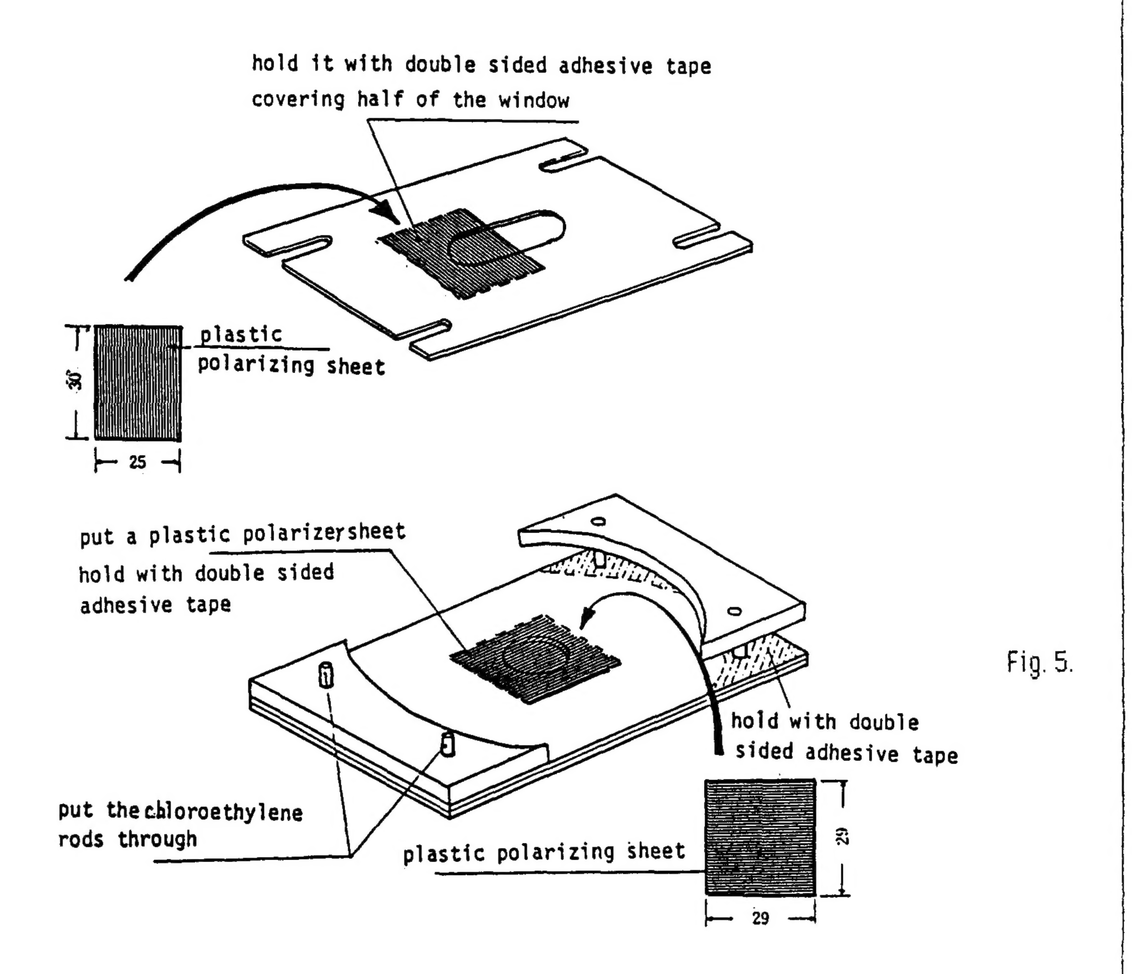


Fig. 5.

7- METHOD OF USE

This equipment is used when observing a thin section of rock under a microscope, or through a loupe, by setting the section into the window of a disk which can rotate freely between two polarizing plates.

(1) Put the thin section of rock into the rectangular window of the rotatable disk, and put the top plate over it.

(2) Observe the section with a loupe or a microscope of appropriate magnification.

(3) Rotate the disk between the overlapped polarizing sheets or on the sheet attached to the base plate by sliding the top plate. The overlapped sheets require a brighter light source.